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(Continuing the Journal of the Allied Dental Societies)

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"DENTISTRY" AND "STOMATOLOGY"

This *Journal* uses the term "dentistry" to signify the science and art of oral health-service in all its local and systemic relationships. The meanings of words, which are not necessarily restricted to *etymological* significance, acquire expanded or new import in accordance with convenience and usage. Thus the term "medicine," which originally meant to remedy or cure, now also means *to make remedial or curative treatment unnecessary.* "Stomatology" is a synonym for "dentistry." We prefer the older term because its use respects both the history of dentistry and the efforts of those who have brought dentistry to its present status.

ENDOWMENT FUND OF THE JOURNAL OF DENTAL RESEARCH

During the past four years, the American College of Dentists, through the agency of its Commission on Journalism, has been giving special attention to dental journalism. During the progress of this study, and until decisions are announced, efforts to increase our Endowment Fund have been suspended, lest any such activity should appear to be related to the endeavor of the College to bring about, by fair and suitable means, the discontinuance of trade-house control of journals that are issued as professional magazines. The annual deficit, larger than usual because of the increase bulk of this Volume, will be liquidated as heretofore by supporters of the cause of professional journalism.

PROCEEDINGS OF AFFILIATED DENTAL SOCIETIES PUBLISHED AS INDEPENDENT JOURNALS WITHIN THE JOURNAL OF DENTAL RESEARCH

The organizations named on the title-page publish all or some of their proceedings on conditions that make each body's group of papers, in effect, its own independent journal within the *Journal of Dental Research.* Papers contributed by organizations are controlled and edited by the official representatives. Reprints of parts of any number of the *Journal* may be obtained for issuance in separate volumes of transactions. See the title page of this Volume, and compare it with those of Volumes V to XI, inclusive.

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SUN YAT-SEN AND MAURICE WILLIAM

Note on Dr. William's new book on international affairs

Maurice William, D.D.S., F.A.C.D., has been engaged in the daily practice of dentistry in New York City for twenty-five years. Without interruption of his professional work he published, in 1921, a book entitled *"The Social Interpretation of History: A Refutation of the Marxian Economic Interpretation of History."* This remarkable book converted Dr. Sun Yat-sen, the venerated first president of the Chinese Republic, from a communist to an anti-communist philosophy. In the current issue of the *Political Science Quarterly*, in an article entitled "Sun Yat-sen and Maurice William," Dr. James T. Shotwell, Professor of History at Columbia University, has written in part as follows:

"Of all the strange chapters in the history of East and West there can be none stranger than this, that the founder of the Chinese Republic and the spiritual leader of the new China found in the writing of an unknown American author [Dr. William] so clear a statement of the hardest problem in his political philosophy that he made the American formulation his own. . . . . The reading of [Dr. William's] *The Social Interpretation of History* by Dr. Sun Yat-sen may yet turn out to have been one of the most important single incidents in the history of Modern Asia, for the consequences were immediate and far-reaching, and have only just begun to show their full extent in the orientation of China. . . . . We have not merely the meeting of two minds but of two civilizations: the American and the Chinese. . . . . *It would seem that the time has come to recognize the mediating work of Dr. William*, which Dr. Sun Yat-sen himself recognized in the *San Min Chu I. How great the service which he rendered, only history will show.*"

Dentists will be interested to learn, further, that Dr. William has lately completed a related volume entitled: *"Sun Yat-sen versus Communism; New Evidence Establishing China's Right to the Support of Democratic Nations,"* which presents not only the facts indicated by the title, but also the evidence on which Prof. Shotwell bases the broad conclusions quoted above. This book, containing a foreword by Dr. Ray Lyman Wilbur, Secretary of the Interior, gives a clue to the internal dissensions among the Chinese since the death of Dr. Sun Yat-sen, and offers a solution therefor; throws new light on conditions that account for the present Sino-Japanese conflict; points out an honorable course for the United States and other democratic nations to pursue in their relations with China, and emphasizes the legitimate economic opportunities for all concerned. *Publisher:* Williams and Wilkins Co., Mt. Royal and Guilford Aves., Baltimore, Md.; *price*, $5.00. Subscriptions may be sent to the publisher. Every dentist who appreciates the *spiritual and intellectual importance for dentistry* of constructive public service *by dentists* will wish to study Dr. William's important work.—*William J. Gies, Columbia University, February 21, 1932.*

Quotations on the Status of Dentistry

The greatly improved standing of the dental profession among the professions . . . . is one of the most striking changes in public opinion that I have witnessed during my seventy years of observation of educational progress. . . . . I do not think I have seen during my seventy years of observation of the professions and the means of training them any change so great as that which has taken place in regard to the dental profession, and to the means of training dentists.—*Charles W. Eliot, President Emeritus of Harvard University*, on "The progress of dentistry and of the dental profession." *Address* before the Dental School Society of the Phillips Brooks House Association, Harvard University, December 8, 1924; Harvard Dental School, 1925, pp. 14 and 19.

I think it unlikely that physicians, unless they have a particular interest in the border subjects between medicine and dentistry, will maintain a permanent interest in dental research. This interest may be fostered for a period of special grants, but after these grants are used up or the individual matures, he will probably revert to medicine and not be a permanent investment for dentistry. . . . . The nucleus of . . . . [the] research group [for the advancement of dentistry] in my opinion must be dentists who have had the dental training and have a permanent interest in this field, who have taken the time to get additional training in some of the preclinical sciences. This of course corresponds to the make-up of the preclinical science group in medicine today. I feel a strong conviction, therefore, that individuals who would help dentistry should first help to develop research workers with dental

(Continued on p. 3 of the cover)

THE PROPOSED AMERICAN BOARD OF STOMATOLOGY[1]

EDWARD FRANKEL, JR., M.D., F.A.C.S., WILLIAM B. DUNNING, D.D.S., F.A.C.D., AND JOHN OPPIE McCALL, B.A., D.D.S., F.A.C.D., F.A.A.P.

New York City

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I. INTRODUCTION

Edward Frankel, Jr., M.D., F.A.C.S., President

We had planned to devote this evening to a consideration of the relation of dental infection and defects of mastication to gastro-intestinal disturbances. But, since our last monthly meeting so much interest has been shown in the proposed American Board of Stomatology, that your Program Committee decided to make this session an open meeting to consider such a Board. Perhaps a few words relative to the origin of the idea of such a Board would be in order. Last spring two friends, one a dentist and the other a medical man, happened in the course of conversation to talk about the possibility of having some such standardization for stomatology (or mouth conditions, both medical and dental) as exists for other branches of medi-

[1] Symposium at a meeting of the American Stomatological Association, Columbia University Club, 4 West 43rd St., New York City, December 8, 1931.

cine, looking upon stomatology as a definite branch or specialty of medicine. These two men were Dr. L. R. Cahn and myself. The idea of having an American Board of Stomatology originated in the mind of Dr. Cahn. Since I had been very much interested in the value of both the American Board of Otolaryngology and the American College of Surgeons, we determined to ascertain whether this idea would appeal to others. Several of our mutual friends having evinced an interest in this project, all of us met for the purpose of considering the possibility of initiating an American Board of Stomatology along the same lines as the American Board of Otolaryngology and similar boards. Our group arranged to apply for a charter of incorporation. It must be distinctly understood that this original group intended merely to serve as a Board of Directors, or as an executive committee, and not to be the ultimate or final Board, nor were they in any way to be considered examiners on that Board. To this end, namely, to form an executive committee, this group, on June 25, 1931, signed the following statement:

"*The undersigned* eight duly licensed members of the medical and dental professions in the City of New York, actuated by a desire to further the science of stomatology in the interests of the public welfare and for the elevation of the professional standards of those members of the medical and dental professions active in the field of stomatology, and for the further purpose of fostering postgraduate work, research and study in the field of stomatology, do hereby agree to form a membership corporation under the Laws of the State of New York, to be known as '*The American Board of Stomatology*,' and do hereby agree to act as the Board of Directors of said membership corporation upon the formation thereof, and to adopt such rules, regulations and by-laws as may be necessary to more fully effectuate the broad purposes herein enumerated as the motivating ideas in the formation of said corporation." (*Signed*): *Charles F. Bödecker*, D.D.S.; *Lester R. Cahn*, D.D.S.; *Henry Sage Dunning*, M.D., D.D.S., F.A.C.S.; *William B. Dunning*, D.D.S.; *Edward Frankel, Jr.*, M.D., F.A.C.S.; *Harold J. Leonard*, D.D.S.; *Alfred Owre*, D.M.D., M.D.; and *William D. Tracy*, D.D.S.

In due course, application was made at Albany for the granting of a charter (July 8, 1931). Application for this charter was purposely made in the state of New York, because it is universally recognized

that the Regents of this state represent as high an educational factor as any in this country. Being educational in its purpose, we anticipated that the project would be brought before the Regents for their consideration before such a charter could be granted. Had this original group wished to obtain a charter without any difficulty, they might have applied to many other states, as for example, Maryland or Delaware; they deliberately sought the approval of the New York State authorities.

In due course this matter came before the Attorney General of the State of New York, and he in turn, as anticipated by our group, referred it to the Regents as being educational in character. The Board of Regents referred it to the Board of Dental Examiners, upon the opinion of which would, to a great extent, depend such action as the Board of Regents would ultimately take in regard to the granting or denial of a charter. The Board of Dental Examiners called for a public hearing on this matter. This hearing was held in the Hotel Pennsylvania on December 3 just past. At this public hearing the Board of Dental Examiners listened to arguments both for and against the formation of the proposed American Board of Stomatology, and decided to defer giving an opinion until such time as the matter could be brought before them in a more comprehensive way.[1] We, on this executive committee or initial Board of Directors, finding that the formation of an American Board of Stomatology was opposed by some reputable dental practitioners, realized very presently that we had made an error, in that it would have been wiser to put the matter before dental societies and medical societies first, rather than to proceed with the application for a charter, expecting later to invite groups of medical and dental practitioners to join us after incorporation.

At the public hearing, Dr. William B. Dunning, as spokesman for the executive committee, presented a very concise and comprehensive digest of our aims and purposes. I followed with a statement voicing the ideas of the Board as well as giving my personal views. Thereafter the other members of the executive committee who were present spoke. Our program this evening is a discussion of the *need* for such

[1] See the related comment by Dr. Walker on page 21.

a Board. Because I think my statement at the public hearing will clarify the purposes of this proposed Board, I will now read it.

"As the only medical man, per se, on the proposed American Board of Stomatology, as well as being the Chairman of that Board, and in view of the fact that letters have been written and statements issued questioning my personal motives in accepting membership on the Board, I feel impelled to make a statement clearly defining my stand in the matter under consideration. For many years I have been profoundly interested in fostering a closer understanding and a better relationship between dentists and physicians since, in my personal contacts with dentists as an otolaryngologist for a quarter of a century, I have met them on more or less common ground. My belief concerning the formation of the proposed Board was that *we*, who subscribed our names to the proposed charter of incorporation, did so purely as an initial Board of Directors for organization purposes only, such as one finds in articles of incorporation of any business company. This is a legal requirement. The application for a charter was a preliminary step merely for the purpose of setting the 'ball rolling.' It must be clearly understood that there was no intention of limiting the Board to the original eight men, nor was it by any means intended that these eight men should serve as a Board of Examiners nor as a permanent Board of Directors. It was our belief that, after proper expansion by the inclusion of such men as would be interested in the movement and who would become additional members of the Board, proper methods of procedure would be agreed upon by the members of this amplified Board to the satisfaction of all concerned, individual or organization. I have stated repeatedly that the ultimate Board should be composed of men of the highest professional reputation, scholarship, and integrity.

"Since 1927 I have been the Director of the American Stomatological Association, and its President since 1928. The aims and purposes of this Association are, first, to promote the development of the science of stomatology, and second, to establish and maintain a closer relationship and a better understanding between physicians and dentists. I wish definitely to make the statement that the American Stomatological Association, as an Association, has had nothing whatsoever to do with the formation of the proposed American Board of Stomatology, although it is coincidental that the members of the proposed Board happen also to be fellows of that Association. This coincidence occurred in consequence of these men having been drawn together by a common bond, namely, a profound interest in stomatology.

"I realize now that our method of approach may have been ill-advised, and as a result we have been criticized because our motives have not been properly understood. It is my positive conviction that the time is rapidly approaching when an American Board of Stomatology will be of equal importance and will receive equal recognition with the American Board of Otolaryngology, the American Board of Ophthalmic Examiners, and the recently formed American Board of Obstetrics and Gynecology. Opposition to the proposed American Board of Stomatology has come from leading dentists for whom I have the highest regard and whose opinions I greatly respect. This opposition has been based, I believe, on a misunderstanding of the aims and purposes of the proponents of the American Board of Stomatology. I am certain that a proper conception of the motives and principles actuating the formation of the American Board of Stomatology, will remove all serious objections. Dr. William B. Dunning has clearly and eloquently stated those aims, purposes and motives, and his statement requires no amplification." [Dr. Dunning's statement follows.]

Statement read by Dr. William B. Dunning, in behalf of the proposed American Board of Stomatology, before the New York State Board of Dental Examiners, at the public hearing concerning the American Board of Stomatology, at the Hotel Pennsylvania, New York City, December 3, 1931.

"In compliance with the notice of and request to attend this hearing, we, the undersigned citizens and legal practitioners of medicine and dentistry in the State of New York, having filed an application to incorporate as The American Board of Stomatology, respectfully submit the following statement:

"1. The mouth, as the portal of the human body, and as related directly and indirectly with all structures and tissues beneath the cranium and above the esophagus and trachea, is a region of the first importance to life.

"2. Practitioners in the field of stomatology today, with certain notable exceptions, are (a) those who have graduated in the accepted dental curriculum and who lack training in clinical medicine adequately to cope with oral and associated pathology other than dental pathology; and (b) those graduates in conventional medicine, interested in oral problems from the general standpoint but who lack knowledge of local conditions, especially in relation to dental pathology.

"3. The welfare of the public is not properly safeguarded while this discrepancy continues between practitioners who assume the responsibility of life or death in dealing with oral conditions.

"4. Whatever may be the adjustments in medical and dental education in the future making for unity in training, it will always be desirable, indeed necessary, to have some qualifying test for the stomatologist, as in the case of the ophthalmologist, the gynecologist or any other specialist in medical practice.

"5. With a view to this end, the application for the incorporation of a body to be called 'The American Board of Stomatology' was submitted, with specific purposes outlined in such application, and with the ultimate object of creating a large group of men specially trained and recognized as stomatologists.

"6. It was *not* the purpose of the incorporators to interfere in any way with the status of any licentiate under the dental or medical law, nor was it their purpose to seek any profit in the operation of the Board. It is stipulated that the Board shall own no property and that no member shall receive a salary.

"The above outlines in brief the general purpose in making such application for incorporation. We are well aware, Mr. Chairman, of the opposition at large which has developed, pending this hearing, notably on the part of organized dentistry. It is the principal contention of our critics that such a proposal in order to have the support of organized dentistry and medicine should follow a broad discussion by recognized professional organizations and not proceed from any group of persons, however disinterested may be their intention. This we submit is a criticism on our method of approach, not in any way to be confounded with the merits of the proposal that the specialty of Stomatology be given official standing. We realize however, that this entire subject should now be given wide publicity and receive mature consideration before any action can wisely be taken; and with that in view, and fully convinced of the basic truth of our contentions under headings 1 to 6 inclusive, we now request, respectfully, that any recommendation of the Board of Dental Examiners be deferred for the present pending a new approach in such way as to meet with general approval as serving the best interests of all concerned." (Signed by the eight applicants for incorporation named on page 2.)

"Because of insidious and unfounded accusations that I do not deserve and which are, in fact, refuted by my professional record and known career, I want to deny that I have or ever have had any connection whatsoever with the Columbia University Dental School, and I wish to state that only recently, to the great surprise of my colleagues, I resigned as instructor in the Columbia University Medical School. My opinions, views and position on professional conduct and procedure are therefore unbiased by any instant academic affiliation. I wish to add that I do not subscribe to the tenets of the Columbia University Dental School concerning possible changes in the curriculum, since such changes would not concern me in any wise, except in a disinterested manner, as an observer of medical education. I am *not* a dentist. It has been my purpose to promote a cause, without any personal motive, that may bring the two professions together, meeting on a common ground. I concede the point that we, in our enthusiasm, may have approached the organization of the American Board of Stomatology from the wrong angle, but I am convinced that in principle there is a need for such a Board.

"In order to bring this matter into the open for frank and full discussion, I have arranged to set aside the announced scientific program for the American Stomatological Association on next Tuesday evening, December 8th, and instead, the business of the evening will consist of a free discussion of the proposed American Board of Stomatology. 'The Need for Such a Board' will be presented affirmatively by Dr. William B. Dunning. 'Is

such a Board necessary?' will be discussed by Dr. John Oppie McCall. General discussion will follow. On that occasion, the arguments in favor of or against this proposed Board will be, for the first time, presented before the American Stomatological Association. I shall be glad to see other medical and dental organizations which may be interested in this movement take the matter up for open discussion at their future meetings in a similar manner.

"The subject matter is one of improved medical and dental education. As a surgeon, teacher and student, I am deeply interested in any movement or organization that seeks to promote or improve medical education. All discussion should be on a high and impersonal plane. Personal motives and feelings should play no part, and any attempt to interject personal issues or individual preferment should be frowned upon. Ours is a profession and not a business. It is affected with a public interest and intended for human welfare. No movement proposing advancement in study or teaching, however ill-advised the method of organization, should be opposed solely on that ground. The best interests of the professions, medical and dental, dictate full-hearted coöperation. Public health and welfare being our aim and purpose, united support should be freely accorded. As for myself, I have nothing to gain except the knowledge that once again I have been of some slight assistance in the promotion of medical advancement and public welfare."

One more point I wish to bring out most emphatically: *the true purpose of the proposed American Board of Stomatology is the promotion of postgraduate study for both dental and medical men.* It is not concerned in any way with undergraduate or pregraduation activities; that is to say, it has nothing to do, and it proposes to have nothing to do, with the curricula of either medical schools or dental schools. *It is purely to promote, foster, and encourage postgraduate study.*

II. THE NEED FOR SUCH A BOARD

William B. Dunning, D.D.S., F.A.C.D.

I regret that it will be necessary to indulge in a few repetitions in making the following statement, because much of the material was presented at the public hearing last Thursday (page 5). However, in the interest of the present discussion, such data should be repeated, and I ask your patience while I do so.

Last week, in this city, a joint meeting of physicians and dentists was held at the Hotel Pennsylvania. Several hundred members of "both" professions attended throughout a program which filled the afternoon and evening, and which consisted of eleven papers, all bearing upon the relationship of dentist and physician in the treatment of oral, nasal, eye, ear and throat conditions. The meeting was an impressive incident in a long series of similar gatherings in this city in recent years. The obvious and very commendable purpose was to "get together" men having a common interest but who met, nevertheless, as comparative strangers. All of these men are devoting their lives to the study and care of the same patient, the common human being, but in so many ways do the two groups differ that it may fairly be said they speak and think in different languages.

These educational differences, these differences in fundamental conceptions of biological problems and in methods of approach, constitute a serious discrepancy of knowledge and opinion in the treatment of conditions affecting life and health, from which every patient is liable to suffer. The need and the desire on the part of thoughtful and conscientious practitioners in the oral region to "get together" are more and more clearly seen. How may they do so? Two possible ways should be considered. First of all, some rational readjustment of medical and dental education should evolve in the course of time to end the present anomalous, illogical, and harmful effects of two "separately organized" *medical* professions. But it is admitted that many years may be needed to bring about such a change. That is not the subject of discussion this evening. Secondly, as a way to meet "the instant need of things," it is possible and should be practicable for medical and dental men of today to agree upon standards in the practice of stomatology and of requirements which the stomatologist should meet. This means the recognition of the oral specialist by a competent and properly organized body. To this end the founding of the American Board of Stomatology has been proposed, which shall function in spirit and purpose similarly to the boards in other medical specialties. An application for incorporation has been filed under the laws of the State of New York, but, if granted, it is hoped the operation of the Board will become of national scope. The act of incorporation is a legal requirement.

In order clearly to set forth what is meant by the terms "stomatology" and "stomatologist," the following definitions should be given here:

Stomatology: the sum of knowledge concerning the mouth. That branch of medical science which treats of the anatomy, physiology, pathology, therapeutics and hygiene of the oral cavity, the tongue, teeth and adjacent structures and tissues, and the relationship of this field to the entire body.

Stomatologist: an oral diagnostician. A licensed *dentist* or *physician* who through knowledge and skill is competent to diagnose and treat, *or prescribe the treatment of*, oral and dental diseases and abnormalities of whatever nature, with special reference of such conditions to bodily health. The stomatologist may practise the art of oral and dental surgery in any of its departments, with effectual ability to recognize and evaluate oral, nasal, otolaryngological, sinus or general pathology; or his center of interest and practice may lie in those regions *associated* with the oral cavity, with definite theoretical knowledge of oral and dental requirements. The basic idea is that he shall be *actively intelligent in all matters proper to the field of stomatology*, in the comprehensive interpretation of that term.

The main purpose of the Board is that of a liaison organization between dentistry and medicine, as the professions stand today—with a view to bringing about a closer understanding and ultimate union of the now artificially sundered members of the great healing art. It is to be as free as humanly possible from the taint of politics or the control of any vested interest. Leaders among dental and medical practitioners, who are interested in the broad aspects of this problem and whose recognized abilities and standing require no further certification, are being invited to membership on the Board. When fully organized, election to membership will entail as a prerequisite, examinations oral or written, so that election to membership will in itself be a certificate of competence in the field of stomatology. The Board proposes to formulate and recommend, to the several institutions engaged in the teaching of dental and medical science, such courses of graduate instruction as may be deemed necessary and important for the development of the field of stomatology. The Board will own no property, and no member shall receive a salary.

Application for incorporation pursuant to the Membership Cor-

poration law having been made in due form, the matter was referred to the New York Board of Regents, and by them to the State Board of Dental Examiners, for recommendation. This application was signed by Charles F. Bödecker, Lester R. Cahn, Henry S. Dunning, William B. Dunning, Edward Frankel, Jr., Harold J. Leonard, Alfred Owre, and William D. Tracy. At a public hearing at the Hotel Pennsylvania on December 3, 1931, the Board of Dental Examiners received statements from both proponents and opponents of the plan. Following a discussion for two and one-half hours the Examiners, in executive session, granted the request of the proponents that any recommendatory action of the Board be deferred for the present, pending a discussion at large in dental and medical associations.[3] The meeting this evening, being devoted to the subject, will record the first open debate on the merits or demerits of the plan to create an American Board of Stomatology.

Much adverse criticism has been heard of the wording of the "certificate of incorporation." As one of the signers of that document, and speaking for the others, the present writer wishes to assure all those concerned that desirable alterations or corrections can and will be made. We fully realize that the plan under consideration can be useful *only* with the approval and support of organized dentistry and medicine. The legal steps already taken were necessary, and pursuant to prescribed forms, but in other respects the limited foresight of a few persons will now be enlarged and corrected by that of many. There need be no fear that any self-perpetuation of individuals in office will pervert the ideals upon which the plan is founded. One objection to the organization of an American Board of Stomatology is the assertion that such a specialty does not yet exist, hence a body to be compared to the American Board of Otolaryngology or the American Board of Ophthalmic Examiners, would be an absurdity, for the two organizations mentioned were formed only after those specialties had been long established. We consider this objection a mere quibble, for everyone knows that the treatment of dental and oral conditions is as old as medicine itself. We are seeking to *improve* knowledge and skill in a field of practice coeval with civilization.

[3] See the related comment by Dr. Walker on p. 21.

Another general objection is the assertion that existing agencies will do everything needed which the Board proposes. Here is simply a difference of opinion on what is needed. We contend that dental and medical examining and licensing boards today do *not* require for registration adequate proof of the candidate's fitness to practise stomatology. As a matter of fact, practitioners in the field of stomatology today, with certain notable exceptions, are (a) those who have graduated in the accepted dental curriculum and who lack training in clinical medicine adequately to cope with oral and associated pathology other than dental pathology; and (b) those graduates in conventional medicine who are interested in oral problems from the general standpoint, but lack knowledge of local conditions, especially in relation to dental pathology.

Since the most important part of this meeting is to be the open discussion following, I desire now to close with the following summary of reasons why an American Board of Stomatology should be established:

1. The *physician of the mouth* is needed. Neither the dental nor the medical graduate today is equipped to recognize and treat mouth pathology in the broad sense.

2. The function of the Board will *not* encroach upon the province of conventional dentistry, but become an incentive for the broader training of both dentists and physicians.

3. Whatever the future relationship of dentistry to the mother profession, the specialty of stomatology will always exist, with the same need as of today for the competent and fully trained specialist.

III. IS SUCH A BOARD NECESSARY?

John Oppie McCall, B.A., D.D.S., F.A.C.D., F.A.A.P.

I ask the privilege of making one or two preliminary comments before beginning the reading of my paper. I wish first to have it understood by all, as I know it is understood by Drs. Dunning and Frankel, that the objections to this Board which I have already voiced editorially[4] and also at the public hearing last Thursday are on the

[4] McCall: The proposed American Board of Stomatology, *New York Journal of Dentistry*, 1931, i, pp. 441–443; November. Reply to Dr. Dunning, *Ibid.*, pp. 507–508; December.

merits of the question and have no personal bias whatever. In voicing these objections I have chosen as vigorous a method of expressing myself as I could command, because I felt that if I were right, only the most vigorous expression of that opinion would be likely to sway the judgment of those with whom I might come in contact. But I have a very high opinion of every one who is concerned in this question and of their motives. Some of Dr. Frankel's introductory remarks gave me a new view of certain aspects of this question. I will ask you to interpret some of the comment in my paper as having been written at a time when I was not in full possession of those facts. Since I have commented editorially on the method followed by the proposed founders of the Board, I shall here confine myself to the question of *need* for such a Board.

Consideration of this question necessitates an evaluation of two factors: one is the generally accepted and also the legal status of dentistry together with its limitations, if any; and its evolutionary trend as indicated by its past development. The other factor is stomatology; what it is, its evolutionary trend as indicated by past development and as stated by the proponents of the movement; what it has to offer that is not contained in dentistry, and how it is to be distinguished from dentistry. And after considering and comparing dentistry and stomatology, we have also to determine the possible benefits to be derived from the creation of a Board, not benefit to the dentists or to the stomatologists, but to the public. What is dentistry and what is its status in the minds of dentists, physicians, lawmakers and the public? Dentistry is the science and art of diagnosing, treating and preventing diseases of the teeth and their supporting and contiguous structures. Dentists may, with the full consent of the law, perform operations on the teeth, on the periodontal tissues, and on the mandibular and maxillary bones. They may operate on a ranula or treat a diseased antrum, remove tumors from any part of the mouth, apply therapeutic remedies to the oral tissues or administer drugs internally, and administer general anesthetics. That not all dentists do all these things, and that under present educational conditions, not all dentists are invariably able to diagnose all disease conditions presented in their patients' mouths, are conditions which do not alter the fact that any dentist can, within his profession as

provided for under legal statutes, be trained to make a diagnosis of oral pathologic conditions, and to treat the same. We find then that the dentist has very broad prerogatives as regards his field of endeavor, and that he therefore is under no limitation within the mouth. He may seek to influence its health by either local or general means.

Considering the opportunities conferred on the dentist by legal statute, and by the general consent of the various professional groups most intimately concerned, the question may arise as to whether he is developing his field of health service from both practice and science angles in such a way as to indicate that satisfactory progress is being made. I ask you to consider that word "progress." It is progress, and not the actual attainment at any one time, we have to consider. It seems unnecessary in this short paper to review in detail the beginnings and development of dentistry as a profession. It will be generally accepted, I believe, that the profession, starting simply as a craft and developing itself against the odds of public indifference, and neglect by the medical profession, has brought itself to a point where it is accepted today as a true profession by the best qualified impartial observers. I refer here, for example, to the recent recognition of dentistry by the American Association for the Advancement of Science. This Association, made up of scientific societies of the highest rank and representing all known branches of science, has accepted the American College of Dentists in association in its group on medical sciences. In addition to this it may be mentioned that dentistry is recognized as a profession by common consent of the medical profession, whose most intimate concern such recognition would naturally involve, and also by legal statute.

The next question is: Has dentistry indicated by its past development that it is awake to the need for further advancement, and is it capable of making such advance? It is perhaps around this question that our principal interest centers at the present time. Probably the best single answer to this query is to be found in the very lively interest displayed by dentists in the biological aspects of their professional work as exemplified in the dental literature of the day, the interest displayed in biological topics in dental meetings, and in other directions. I do not seek to imply that the major interest of dentists is

in the biological side of their work. The technical aspects of their work continue to receive much consideration, and must inevitably continue to do so. It is in fact the necessary interdependence of the highest development in engineering and esthetics, coupled with the equally necessary consideration of the biologic factor, which makes it essential that dentistry should maintain its own body politic, its educational identity, and its legal status. I still maintain, however, as I have just stated, that dentists are manifesting a very lively interest in the biologic aspects of their work.

I think it is safe to say that interest in a subject is the first requisite towards success in acquiring knowledge regarding it. The other requisites have to do with the application of effort, and this in turn is fostered or hindered according to the availability of facilities for study. It is with regard to the availability of facilities for the development of advanced knowledge that dentistry is most severely handicapped. I think it is safe to say that dentists and dental investigators, working with the same zeal that they display today, could and would advance knowledge in regard to the biologic aspects of dental science with a rapidity that would satisfy the most captious critics of dentistry, if they were provided with the facilities and resources available today to investigators within the field of conventional medicine. Evidence of the desire to acquire more knowledge to which I refer is readily available. Essayists at dental meetings, writing on such topics as nutrition, bacteriology, root-canal therapy, periodontia, etc., are eagerly questioned. Their only embarrassment is that, owing to the meager opportunities for research, they cannot answer all the inquiries directed to them.

No dentist or physician is satisfied with the present state of knowledge regarding dental subjects nor are dentists satisfied with the current methods of practice. We must remember, however, that our knowledge being incomplete we cannot expect dentists to discard any accepted method of practice which has not been proven scientifically to be wrong. For example, our leading advocates of root-canal therapy admit that many root canals become infected after being treated and filled. Yet they are also able to point to many instances in which root canals have been filled, and in which histologic and bacteriologic studies indicate clearly that the canals are not infected. Under such circumstances it is obviously not to be ex-

pected that these dentists will discard this method of preserving teeth. And it is also natural that they should do just what they are trying to do, namely, improve the methods of root-canal therapy and check the results obtained.

So much for investigation and practice. Dentists are conscious, perhaps more so than any other group, of the shortcomings of dental education as it is carried on today. We hear much of the need for more medical training in the dental curriculum. It may surprise some of you to learn that, in more than one dental school of which I have intimate knowledge, one of the chief obstacles in the way of this very desirable improvement is presented by the medical profession both through its individual members and its schools. A considerable number of dental schools would gladly increase the amount of medical training given to their students if they could find out how to do it without requiring their students to take the entire medical course. The obstacle I mention is not one which is placed deliberately in the path of the dental student. It proceeds from two sources. The first is a lack of understanding of dental problems by physicians who, as individual members of medical faculties, would be charged with the task of giving the instruction. The second source is the financial difficulty involved in providing for the instruction of the dental student in the medical school and particularly in the hospital. As chairman of the Curriculum Committee of the New York University College of Dentistry for some years, I consulted frequently with members of the medical faculty in the effort to develop advances in medical training for the dental undergraduates in that college. I therefore feel competent to make the statements herein presented in regard to this aspect of the subject.

Another confirmation of my views is to be found in the public and private statements of Dean Winternitz of the Yale Medical School, where special scholarships for dentists have been established. He has stated that one of his objects in giving this special training was to create a group of men having first-hand knowledge of the problems of dentistry and also a grounding in the fundamentals of medicine, from which group there might be recruited teachers for dental schools capable of planning courses of instruction for dental students which would provide for them the necessary biologic knowledge.

Lest it seem that I am complacent regarding the present status of

dentistry, let me say that I am far from satisfied with present conditions in practice and in education. But I take the position that dentistry, as now constituted, recognizes its shortcomings, desires to continue to improve itself, and has the necessary capacity and will to bring about that improvement, to the extent that added resources and facilities will permit. The question may then arise: Could the needed resources and facilities be made more readily available if a special group, to be known as "stomatologists," were to be created? I do not see how this can be made to appear as a logical sequence. In the first place, the group would be recruited chiefly from among dentists. This is indicated sufficiently by the make-up of the group of incorporators of the proposed American Board of Stomatology, which contains five men who have the degree of D.D.S. only. We may wonder first if the medical profession is going to be impressed by the mere self-creation of a group calling themselves "stomatologists," but presenting no definite qualifications as a basis for assuming that title. And we may then wonder whether the request of this group for financial backing would be more seriously received than have the earnest requests made in the past by dental educators who have been held in high esteem, despite the fact that they did not assume an additional title. I do not wish to have it appear that I am basing my arguments entirely on grounds of finance. Yet it is a fact which must be faced; the self-styled "stomatologists" would not be able to advance medico-dental science any more rapidly than dentists are now doing, unless they can command adequate financial assistance.

We now turn to stomatology: what it is, and what it has to offer. Stomatology might be said to have come into existence in this country in 1881 when Dr. Eugene S. Talbot induced the American Medical Association to create a Section on Stomatology. His object in bringing about this development was essentially that which has been set forth by the proponents of the American Board of Stomatology. This Section had one point of difference from the present movement, in that membership in it was limited to members of the American Medical Association, who therefore were possessed of the M.D. degree. This history of the Section is significant. Despite the earnest and energetic efforts of Dr. Talbot, the Section failed to arouse sufficient interest in the medical profession to assure its continuance,

even after the revelations of the past twenty years had proclaimed loudly the close interdependence of medicine and dentistry. The Section was discontinued in 1925, when it was generally admitted, as an additional reason for the discontinuance, that dentistry was rapidly assuming its full responsibility, and it was impractical to continue the Section. We thus see that the evolutionary trend of stomatology, as exemplified by the past, has been quite the opposite of that exhibited by dentistry. Can we expect that the future will show an about-face in this regard? What is stomatology and how does it differ from dentistry? Definitions have been conspicuous by their absence. Dr. Dunning has just repeated the definitions given in his letter in the *New York Journal of Dentistry* (page 9, above), which in my reply in that journal I suggested were the *beginnings* of definitions.[5] But Dr. Dunning's definitions are really explanations. They are too long and too complicated to serve as definitions. And by their length and complexity, they indicate clearly that the self-styled stomatologists do not themselves know just what the outlines of their so-called specialty are. The definition of stomatology is too broad to be satisfactory. It does not in itself provide a means of distinguishing between stomatology and dentistry. If we were to accept this definition, we would be compelled to ask for a re-definition of dentistry. All of the subjects mentioned in this definition are being taught in every dental school in this country. It does not follow that to *call* them "stomatology" will, by that simple act, result in their being taught better or more fully.

Dr. Dunning defines a stomatologist as an oral diagnostician. This definition, even when amplified by the very elaborate explanation that follows it, does not provide a distinction between stomatologist and dentist. Every dentist must, of necessity, be an oral diagnostician and it is impossible to draw a line of demarcation as to where the diagnosis of the dentist should stop and the diagnosis of the stomatologist should begin. The extent of his ability in diagnosis does not provide an essential or legal basis for making a distinction. Variation in the skill of individual dentists in oral diagnosis is to be expected, according to their native ability, training, and opportunities for observation. The same thing may be said, however, about

[5] McCall: *Loc. cit.* (footnote 4).

physicians. Referring to the field of medicine, it may be noted that some physicians, through superior ability and broad experience in practice, come to acquire exceptional ability in diagnosis, but I have yet to learn that these men constitute a definite group set aside from the rank and file of the medical profession. I might elaborate on this point at greater length, but believe that the foregoing sufficiently states the fundamental situation. The other points mentioned in Dr. Dunning's definition of stomatology are too vague to furnish a basis for satisfactory academic discussion. They do display, however, a leaning towards the idea of bringing about the evolution of a master-dentist-technician method of practice, which has been freely discussed by several writers and which I, personally, feel should not be introduced into the field of oral health-service. I might add, in this regard, that in the field of medicine there has been no development of a similar method of practice, in spite of the many opportunities presented in hospital and clinic service. Since it has not been made clear that there is any essential demarcation between stomatology and dentistry, or since it has not been shown that stomatology is anything which dentistry is not, there seems to be no good reason for creating the title of "stomatologist," nor for creating an artificial distinction between one dentist and another, which would be the natural outcome of the creation of an American Board of Stomatology.

Some interesting and pertinent matters bearing on this subject were brought out at the public hearing held by the New York State Board of Dental Examiners, December 3, 1931, to which both Dr. Frankel and Dr. Dunning referred. It was said, for instance, that the proposed Board would extend its recognition to certain physicians as well as dentists. Dr. Waldo Mork, discussing a statement by Dr. W. B. Dunning as to physician-stomatologists, said: "I do not believe that the physician has a right to fill a tooth any more than the dentist has a right to remove a diseased tonsil." Dr. Dunning said in reply: "I think the answer to that is that the Board of Stomatology will see to it that any M.D. who aspired to fill teeth would have to come up to the proper requirements, and demonstrate his skill, before he would receive the qualification of the Board." Even if we were to discount the possibility that physician-stomatologists might desire to perform operations that are ordinarily performed by dentists, we

must realize that physicians so recognized, would undoubtedly undertake to diagnose all sorts of oral conditions and direct their treatment. Such a state of affairs would bring back the confusion of the early focal-infection era, when many physicians ordered extractions of teeth on their own diagnosis. But the confusion under the new condition would be a hundred times worse. Such statements as that of Dr. W. B. Dunning, also another made by Dr. H. S. Dunning—implying that dentist-stomatologists should be able to diagnose and treat disease conditions of the pharynx, and others made at the hearing—indicate a confusion and lack of clarity in the minds of the incorporators of the proposed Board. I believe it is self-evident, in view of this state of indefiniteness on the part of those who profess to know what stomatology is, that it would be most unwise to create a Board which in turn would attempt to create a specialty.

At the hearing above referred to, letters were read from the deans of several dental schools, all of them in opposition to incorporation of the proposed Board. I offer an extract from a letter from Dean Turner, University of Pennsylvania:

"If the Board is not approved and supported by the dental profession, it is very evident that the value of its influence in affairs in relation to the public will be very limited. The Board proposes to evaluate educational facilities, personnel, etc. It is the feeling among dental educational institutions that gratuitous education and advice from self-appointed advisers are not required. It would seem that the Board has little chance to exercise its functions in this respect."

We come now to the question as to what conditions might be required to enable a dentist or a physician to become a stomatologist. If we are to judge by statements so far available, or if we are guided by the personnel of the proposed board, we find ourselves confronted with vague statements and by a group of earnest and able men sincere in purpose, but without a clear-cut program, as I have already pointed out. Dr. W. B. Dunning stated in the *New York Journal of Dentistry* (December 1931),[6] that the movement is "an *attempt*[7] to define the field of the maxillo-facial specialist and others on that

[6] McCall: *Loc. cit.* (footnote 4).

[7] Italic not in the original.

borderline who heretofore have been found chiefly among those holding the degree of M.D. and D.D.S." Needless to say there should be something more than an "attempt to define," before setting up the machinery giving a quasi-legal recognition to stomatologists. Also, if this statement is to be taken as an indicator of the scope of practice of the stomatologist, why is it not necessary for all stomatologists to have both the M.D. and D.D.S. degrees, and why are only two of the proposed Board possessed of both degrees?

This brings me logically to what I consider the fundamental reason why there is no need for an American Board of Stomatology. And that is that there is no specialty of stomatology. I contend that the specialty, if there is to be one, must be created, before a Board is brought into existence. It must evolve, it must find itself, it must crystallize itself, so that it stands forth clearly before both medical and dental professions as a distinct entity. When that situation is achieved, if it ever should be, then it will be time to talk about an American Board of Stomatology. And I might call attention to the fact that this is the course which has been followed by other specialties in both medicine and dentistry. But let us suppose that an American Board of Stomatology were to be established now; we must then ask ourselves: What effects would it have? Surely they would not be confined to the desirable effects of stimulating interest in the biologic aspects of dentistry, as the proponents of the Board would have us believe. I ask these gentlemen to explain how, if a specialty of stomatology were created, this could be done (a) without creating confusion in the minds of the laity regarding the function of dentistry; (b) without lowering dentistry in public appreciation; (c) without retarding the development of dentistry; and (d) without being unfair to the great body of dentists, including the students in the dental schools.

One reason for the creation of the American Board of Stomatology, as given by its proponents, is that they believe dentistry will not evolve into a status wherein it will be able to give proper health service. If their premises for this belief were correct, I should favor this also. But I can look back over a brief period of twenty-five years in the profession and recall similar pessimism on essentially the same topic cropping up at regular intervals during that time. And I have seen dentistry make much progress along the lines we are dis-

cussing without the necessity of starting a revolution. In support of my position let me quote a general conclusion from the *Carnegie Foundation's Bulletin No. 19* (p. 239):

"The success with which dentists have brought dentistry to its present state of usefulness, appreciation, and opportunity, against persistent belittlement as 'merely a mechanical art,' and the strength of the evolution of its scope and function now plainly in progress, indicate unmistakably that the leadership of the dental profession is advancing dentistry toward its full possibilities in health service."

Regarding the present respect in which medicine holds dentistry, let me quote Dr. Marriott, Dean of the Medical School and Professor of Pediatrics, of Washington University, who has written:[8]

"The average American dentist is at least as well qualified to render adequate service in his field of work as is the average otolaryngologist, ophthalmologist or surgeon."

If dentistry is steadily evolving into the full equivalence of a specialty of medical practice, as its evolutionary trend and the opinion of disinterested and intelligent observers indicates that it is doing, why should any one assume that the virtues ascribed to stomatology will not soon be fully incorporated into the evolving dentistry. To try to make dentistry over by the simple expedient of calling it "stomatology" savors too much of the use of patent medicines which claim to make a new man of an invalid over night. Let us not be hypnotized by the scientific sonorousness of the word stomatology.

IV. DISCUSSION

Alfred S. Walker, D.D.S., F.A.C.D. (New York City): Before proceeding with a discussion of the question before the house, I would like to make it clear that the request that the State Board of Dental Examiners defer action was made by the proponents, and further that the State Board of Dental Examiners did not go into executive session following the hearing. The request was received by the Board, but no action was taken.[9]

Dr. W. B. Dunning: That was a misunderstanding on my part (page 10).

[8] Marriott: *Journal of Dental Research*, 1931, xi, p. 809; October.

[9] Dr. Walker is a member of the New York State Board of Dental Examiners —[*Ed.*]

President Frankel: Also a misunderstanding on my part (page 3).

Dr. Walker: I also wish to state that I learned tonight, for the first time, that it was the intention of the proposed American Board of Stomatology to *limit its activities* entirely to influencing postgraduate instruction (page 7).

Stomatology, as outlined by the proponents of the Board, does not differ from what is legally defined and generally accepted as dentistry. The authority sought by the proposed Board, as outlined in the articles of incorporation, notably in sub-section 7,[10] would seriously interfere with existing legally constituted agencies which cover the same ground. The proposed Board is not analogous or even comparable to the Board of Otolaryngology, the Board of Ophthalmic Examiners or the Board of Orthodontia, and similar bodies, because these boards were organized for the purpose of establishing some regulation over specialties that had existed and been recognized as such for long periods. Unlike the proposed Board of Stomatology, they did not seek to create a new specialty. The so-called "no-man's land" referred to by the proponents of this undertaking is, I believe, to a large extent, a figure of speech, or at least an area of exaggerated proportions.

The practice of dentistry, in its legal and generally recognized interpretation, *amply covers the field* up to and where the practice of medicine begins. In the New York statute, for example, the practice of dentistry is thus defined:

> "A person practises dentistry, within the meaning of this article, who holds himself out as being able to diagnose, treat, operate, or prescribe for any disease, pain, injury, deficiency, deformity, or physical condition of the human teeth, alveolar process, gums, or jaws, and who shall either offer or undertake by any means or method to diagnose, treat, operate, or prescribe for any disease, pain, injury, deficiency, deformity, or physical condition of the same."

If dentists, upon graduation, are not prepared to assume their responsibilities because of lack of training, the fault lies with the schools and the State Boards of Examiners. Where medical graduates lack preparedness, the

[10] Sub-section 7 in the "certificate of incorporation," to which Dr. Walker referred, reads as follows: "It shall also be the aim and purpose of this corporation to investigate thoroughly and prepare lists of medical and dental schools and colleges and hospitals to which it will give its approval and which it will recognize as competent to give the highest and best kind of training and practice in stomatology, as well as examine for approval the requisite instructors and attendants in such schools, colleges and hospitals for teaching, training and practice in stomatology."—[*Ed.*]

responsibility lies with the medical schools and State Boards of Medical Examiners. To interpose another specialty, which must necessarily cover an extremely narrow field, but which would demand of its practitioners a broad and intimate knowledge of both medicine and dentistry, would lead to confusion if not a worse condition, since individuals endowed with the authority of "stomatologists" would assume the duties of both dentist and physician.

To re-define dentistry as proposed, would interfere with its orderly development—a development unexcelled by that of any other branch of the healing art. While the proposed charter would clothe the board with vast power and authority, the proponents lack unanimity as to procedure and objective. To say the least, it is a questionable assumption that the schools and the professions would recognize the authority the Board seeks to assume. As a matter of fact, the school representatives have expressed convictions as opposed to gratuitous service by such self-constituted bodies.

Comparisons of the qualifications of graduates of fifteen years ago with the qualifications of those graduating today, are hardly to be considered. Those who are brought into contact with the activities of the dental schools know how teaching has advanced. As a member of the New York State Board of Dental Examiners for the past ten years, the speaker has had personal contact with several thousand graduates of dental schools from all parts of the country. Because of this experience, he is in a position to affirm that dental education is broadening and improving, and that the graduates of 1932 will be better equipped to meet their responsibilities than were the graduates of 1931, just as the graduates of 1931 were better equipped than those of the preceding year, and so on back through the years. Personal visits to a great many of the leading dental schools throughout the country has given him additional opportunities for observation. It is certain that the schools are striving to meet their responsibilities and, with a decidedly encouraging degree of success, school authorities are always receptive and grateful for constructive suggestions from responsible sources.

Statements to the effect that "dental teaching and dental practice are making progress" should not be understood to imply that nothing remains to be desired, but should be taken as a refutation of statements from some quarters that dentistry is not moving forward. I have a firm conviction that better health service will be provided, not by the means proposed by this Board, but by the promotion of better understanding—and in consequence fuller coöperation—between the dentist and not only the specialists in medicine whose fields are directly contiguous to that of the dentist, but

also all other medical practitioners, especially those whose responsibilities are concerned with the unborn and the pre-school child.

In all of the discussion of this subject, the diagnosis and treatment of disease has been emphasized, but little has been said of prevention. According to expectations, as mouth hygiene and other preventive measures are better understood and practised, the frequency of diseases of the teeth and other mouth tissues will diminish. This happy result can best be brought about by a well developed service based upon complete coöperation between existing practitioners. Unless I misunderstand the situation, the promotion of such improved relationships between dentists and physicians was one of the fundamental purposes that prompted reorganization of this Association. It might also be said that the function of organizing propaganda for further advances of dentistry along medico-dental lines, which is one of the stated purposes of the proposed Board, can be more suitably exercised through this Association than through the Board.

Harold J. Leonard, D.D.S., B.A. (New York City): Before taking up the subject of the need for the proposed Board, I shall state my reasons for thinking that dentistry will soon be a branch of medicine. Stomatology in America has had a rather unfortunate history, which has put the name into somewhat bad odor with many physicians and dentists who are otherwise favorably disposed toward a closer affiliation between dentistry and medicine. From 1881 to 1925 there was a Section of Stomatology of the American Medical Association. At first this was confined to graduates in medicine, but during its later years it took in graduates in dentistry as associate members with equal privileges. Its papers were published in the *Journal of the American Medical Association.* It gradually died out and was discontinued in 1925; but no papers from it had been published during the ten years previous, as judged by a search through the indices of the *Journal.* The reasons for its death, it seems to me, were fourfold: (a) It had but a limited interest to dentists. Its papers dealt more and more with subjects of oral surgery, which the dentist could get just as well at the meetings of the American Dental Association. There was so little he could get from these sectional meetings that his strictly dental organizations did not furnish him that it was not worth while to attend the meetings. (b) It was chiefly of interest to the few dentists possessing also the medical degree, who used it, in the opinion of dentists outside, as a means of exploiting their superior attainments. (c) The great development of dental technology from 1890 to 1915 increasingly engrossed the attention of dentists, widened the breach between the two professions, and made it appear to both

professions that they had very little in common. (d) The small attendance at the sectional meetings, together with the fact that no subjects were presented that were not covered by other Sections of the American Medical Association or the American Dental Association, made it advisable to discontinue the Section.

In addition to this set-back, the word "stomatology" has had to bear the burden of having its standard upheld, especially here in New York, by a group some of whose leaders had a very poor professional standing. The American Stomatological Association, since 1927, has had the tremendous task of recovering the name "stomatology," and all that it should stand for, from the odium in which it had come to be held owing to this former connection. The word "stomatology" is so valuable a word, and covers so admirably the science relating to the mouth and teeth, that it should be used. It seems necessary to uncover the reasons for the aversion to it in the minds of fair-minded men, so that it may be clearly seen that it is not "stomatology" that is at fault, but merely those who have used it as a means for self-exploitation.

Knowledge of diseases of the mouth and teeth is rapidly approaching the time when its application in practice will require the full medical training and license. It has already been fairly well proved that susceptibility to dental caries is due to defects in nutrition which can be largely corrected by a carefully controlled diet. Evidence is accumulating that gingivitis and periodontoclasia, malocclusion, hypoplasia of the teeth, and erosion, are similarly the results of metabolic faults. The adequate prevention and cure of these diseases appears to lie in ascertaining these metabolic faults and correcting them. Adequacy in any such diagnosis and treatment involves a deep knowledge of systemic metabolism and disease. The correction of the faults, in many cases, will not prove to be a matter to be handled by a wholesale prescription. The individual reactions to foods and the individual variations in metabolism will undoubtedly require much fine diagnostic discrimination in order to discover and correct the faults in given cases. The teeth may be the only organs apparently affected by the faults, and the dentist or stomatologist is therefore the only one interested in discovering and correcting the systemic difficulties. The oral physician may need the help of other specialists in complicated cases; but it is unthinkable that he should have to depend always on the help of other physicians for the adequate treatment of all his cases. I can see no way out but for the doctor of the mouth and teeth to prepare himself to do, himself, what is necessary in order to diagnose and treat adequately the common diseases in his field.

Other reasons for believing that the practice of dentistry must soon be combined with the practice of medicine are such as the following: (a) The oral physician should recognize mouth lesions which are early manifestations of systemic disease. To do this he needs to know the general field. (b) The dentist is frequently engaged in the treatment of systemic focal-infection disease through his local treatment of foci of infection. To do this safely, he should know the field of general disease. (c) The local surgical services of the dentist frequently lead to serious surgical conditions. General anesthesia may lead to death. In both of these conditions the oral surgeon needs the medical training and license for his own as well as for his patient's protection. The fact that Yale, Rochester, and Tulane Universities all have Departments of Stomatology is an indication that the medically trained stomatologist will soon be a fact. At Columbia, courses in stomatology are being organized at the present time for the medical students; and it is my hope that the full medical training may soon be given to all our dental students. It seems to me that the specialty of stomatology based on full medical training is not very far ahead. In the meantime, until such regularly trained practitioners are available, the field must be covered by those who, by special practice or postgraduate study, have trained themselves. It is to stimulate the training of such a group that the American Board of Stomatology is needed. As an organization outside the medical and dental schools, this Board can do much to get postgraduate courses started in the universities, to interest practitioners in such courses, and to certificate these men to the professions when they have become qualified.

When the graduates in dentistry are all medically trained, the need for such a Board and such extra-legal certification may not be so great. Then, all dental graduates may automatically be stomatologists. Even then, there will probably be room for a Board working for higher standards of service, and acting as a means within and for the profession of certifying those especially well qualified. In the intermediate period it is particularly necessary and desirable to have an organization whose sole purpose is the development of means of bridging the gap between medical and dental practice. Until all dentists have regular medical training, and all physicians have oral diagnostic training in their regular undergraduate curricula, it is necessary to provide for special postgraduate training along these lines for those members of both professions who desire it.

There is no organization at present in existence or in prospect with this particular end in view, except the American Board of Stomatology. The American Stomatological Association has purposes which are in general

sympathy with those of the American Board of Stomatology; but it is not organized for work along the lines proposed by the Board. Neither are other dental or medical societies or committees organized for this work. A Committee of the American Dental Association, which at the recent hearing I understood Dr. Dewey to say had been organized to supervise and promote postgraduate work, will certainly not have its major interest along the lines on which this Board will be working. Neither is it the function of the universities or dental schools to do this work. There is a clear-cut separation of purposes. The universities have it as their primary function to educate undergraduates for their work in life. It is up to the universities to decide whether the undergraduate dental curriculum shall include a full course in medicine. Certainly the Board cannot interfere in this matter. It cannot be too unequivocally stated that, whether or not the individual members of the Board believe in the eventual full medical education of dentists, it is not the function of the Board, as such, to advocate such a measure. That must be left to the educational institutions. Besides the training of undergraduates it is also a function of universities to furnish such advanced or postgraduate courses as are demanded by graduates. The demand, however, must come from outside. The American Board of Stomatology cannot furnish the courses, but it can furnish the demand. It is the function of the Board to create the demand and to request the universities to prepare the courses; it is the function of the universities to give the courses that are requested in so far as their internal machinery will permit.

While the initial Board of Directors of the American Board of Stomatology happen to be mostly members of one Dental Faculty, it must be fairly stated that the Board is not a function of that School. It is intended to include many members who have nothing to do with the School. Neither School, Faculty, nor University authorities have been consulted on the matter. The American Board of Stomatology is a separate and distinct organization not connected with any dental school. Its functions and purposes are entirely different. While its membership is predominantly from one School Faculty, this is a condition which, it is hoped, may soon be remedied. It would be a great disappointment if, after the Board is functioning, postgraduate courses in stomatology could not be organized in several universities throughout the country. It is certainly not expected that any one university will have a monopoly of this work.

There is a need for the development of stomatology. The medical training of dentists is essential if they are to function adequately. Such medical training will probably soon be a compulsory part of the under-

graduate dental curriculum. Dentistry cannot look to medical practitioners for help in solving its problems in practice; they are not interested and, as a group, never will be interested in these problems. Dentists must be prepared to solve their own biological problems. Until such time as dentists are thoroughly trained as undergraduates in fundamental medicine, there is a great need to foster postgraduate training in this line. The universities cannot create the demand for such training. The American Board of Stomatology has been organized to fulfill this function. No other organization in existence or in prospect seems likely to do it. Its purpose is to develop the now indefinite borderland between dentistry and medicine, which neither profession is now covering adequately. It expects to do it primarily by promoting the establishment of postgraduate courses in medicine for dentists, and in dentistry for physicians. Later on it can stimulate practitioners to prepare themselves by an unofficial and intraprofessional system of certifying to proficiency similar to that now employed by various other Boards.

Adolph Berger, D.D.S., F.A.C.D. (New York City): I am in sympathy with what Dr. Leonard had to say. I feel that the need for the proposed Board will probably not be very longlived. If we read the signs of the times aright, the time is approaching very rapidly when dentistry will have to become a specialty in medicine. There are many reasons to believe this. For example, the combined medical and dental meeting of last week was rich in suggestions that there is so much of medicine in dentistry that, in order to meet the needs in this respect, dentists must have a thorough knowledge of the basic medical sciences. The gentlemen who preceded me in this discussion have stated the need for the proposed Board. May I not emphasize just one point in this connection, which was implied but probably not quite clearly stated? I am very sorry that I cannot abide by Dr. Frankel's suggestions that there should be no reflection upon existing conditions, and that we should be entirely impersonal in this discussion. If we are to bring to light some of the causes which eventually determined the formation of this Board, we may refer to the present status of dental education. Various palliatives have been offered from time to time to correct some of its deficiencies. Drs. McCall and Walker have mentioned a number of these. We have just heard that as a measure of uplift, some members of the dental profession will be accepted in the American Association for the Advancement of Science. As Dr. McCall mentioned it, I am inclined to ask: In what way will this affiliation or association help dentistry? In my estimation, this is just another of those pacifiers of which many have

been offered to the profession in the past.[11] The American Association for the Advancement of Science is undoubtedly an organization of high standing. Any individual dentist may be proud of and derive satisfaction from the privilege of joining its membership. I fail to see, however, how this will elevate the professional status of dentistry. There is nothing that will elevate dentistry or insure its future status excepting a coördinate affiliation with medicine. The details of this will have to be worked out, and cannot be quite determined at present.

The question is frequently asked: In what way will medicine or more medical knowledge help dentistry? I believe that we must answer this question frankly; we don't know, we cannot fully know. Dr. Daniel C. Gilman, the first president of Johns Hopkins University, in an address at the opening of the Hunt Memorial Building at Hartford, Conn., stated that medical men must be broadly cultured and should be well-grounded in higher mathematics, for upon higher mathematics is founded physics; upon physics, chemistry; upon chemistry, physiology; upon physiology, pathology. Without a thorough knowledge of these basic sciences, one cannot well grasp or practise medicine. And yet we know that few physicians require or use higher mathematics in every-day practice. To apply this idea to dentistry, let us consider some of her specialties. Take, for example, periodontia, in which we have already introduced a worker of lower qualifications, the oral hygienist. I believe that the law provides that the oral hygienist in her work is not to go beyond the free margin of the gum. I am not certain of the exact provision. But we know that the teeth cannot be thoroughly scaled without going well underneath and often beyond the free margin of the gum. Now what does the periodontist do? The periodontist carries his scaling beyond where the oral hygienist is supposed to stop, and adjusts the occlusion of the teeth. If this were to complete the function of the periodontist, we would have to consider his activity as that of a more skillful technician. If the periodontist has a broad knowledge of pathology —of the laws of bone growth and bone regeneration, if he can recognize oral lesions of systemic origin and study the systemic conditions that may affect the periodontium, if he will go into the hospitals and clinics and work there while he studies and treats periodontal diseases, and if he will establish departments for these purposes, his function will be essentially that of a

[11] Dr. Berger evidently misunderstood Dr. McCall's allusion to this matter; see p. 13. Dentists, *as individuals*, have always been eligible to membership in the American Association for the Advancement of Science, but this Association never before (June, 1931) recognized the dental profession *as such* by accepting a dental organization *into formal affiliation with it*.—[*Ed.*]

medical specialist. I cannot see how qualifications can be obtained for this excepting through a thorough medical education. The requirements for general dentistry, oral surgery, orthodontia, etc., are similar to these.

It is usually said that it is not gracious to speak ill of one's profession. It is not my intention to speak ill of my profession. I am a dentist. I have no other claim to a professional standing than that of the D.D.S. degree. Dr. John B. Murphy, the renowned surgeon, once stated that many appendicitis cases were not diagnosed or operated upon early enough nor in the best way. On this idea was formed his slogan: "get in quick and get out quicker." No one accused Dr. Murphy of being disloyal to his profession, although he wanted to remedy something which he felt was not just right in a phase of medical and surgical practice. So I hope my remarks will be taken in a similar sense. If the proposed American Board of Stomatology intends to eliminate the artificial barrier that now appears to separate medicine and dentistry, if it intends to foster the ideal education that will bring about the training of the type of dentist so well described by Dr. Dunning in his definition of "stomatologist," then I am glad to have this opportunity to extend my congratulations to the men who have had the courage and wisdom to sign their names to the certificate of incorporation.

Charles F. Bödecker, D.D.S., F.A.C.D.[12] (*New York City*): I desire to present the reasons why I very heartily support the formation of an American Board of Stomatology. My principal interest in the Board is the closer approximation of medicine and dentistry that it will bring. When this is achieved the standard of our profession will be raised, and the public will receive a more adequate service. The dentist has assumed the responsibility of maintaining the oral health of his patients, and yet up to a short time ago, he has not been sufficiently well trained to achieve this end completely. The fault with dental teaching in the past was that the mechanical side of our work was stressed to such an extent that the biological subjects were almost entirely disregarded. This has been remedied to a certain extent in some schools, and now dental students are graduated who have a more biological conception of dentistry. But they are still young and lack experience; in ten or twenty years, some of the graduates of today will closely approach our present ideal of a stomatologist. In the meantime, however, is the public to wait until this new group of men season their college training with experience in order to give dental service in the fullest sense of the term?

[12] Dr. Bödecker is a member of the New York State Board of Dental Examiners.—[*Ed.*]

Progress of the dental profession could be hastened if men with ten or twenty years of clinical dental experience would take post-graduate instruction in the biological subjects. Thus they would become better fitted to diagnose and treat the various pathological conditions of the oral cavity. To achieve this end I willingly joined our group in the formation of an American Board of Stomatology, for such a body could suggest plans for teaching the necessary fundamental biological subjects to dental and medical practitioners. Such teaching can only be done properly in the universities, but unless a group of medical and dental practitioners carefully study the little defined field lying between the two professions, no typical and adequate courses could be arranged. If individual dental institutions would attempt to solve this problem, the teaching might vary and no definite requirements of a stomatologist could be formulated. For these reasons I believe the formation of an American Board of Stomatology is necessary, and that such a body will raise the standards of the dental profession and improve their services to the public.

Redford K. Johnson, M.D. (New York City): Dentists seem to know more about this subject than we medical men, and are more actively interested. I have a very healthy respect for one statement made by Dr. McCall, and it is going to be a very difficult hurdle for this proposed Board to jump; namely, that stomatology is not a defined specialty. I am afraid that is partly true. We need to give that question very serious consideration. On the other hand, Dr. McCall and also Dr. Walker in very clear-cut fashion indicated that the paths of dental and medical education are tending to parallel. Dental education improves from day to day and from year to year, and I don't believe that medical men deny that. They also showed that dental education tends more and more to become biological in its background, in other words, to take on a medical coloring. I am very glad to hear it. But doesn't the mere fact that such is the trend indicate a certain waste of energy and resources? Two convergent lines tend to meet. Should we do something to hasten this meeting, or should we do nothing? Being a bit impatient myself, perhaps because of a slightly radical turn of mind, I think we should do something. Every minute that we don't try to do something to help this eventual evolution is a waste, and we can be blamed—all of us who think about this subject at all—for not trying to do something about it. Of course, the men who don't think about it can't be blamed for not trying to do something. On the other hand, I have no answer to the statement of Dr. McCall's that stomatology has not yet attained a defined position. Whether we should wait before instituting the proposed Board

until stomatology has reached this position, or whether we should institute a board first and pull for the eventual outcome, is the question to decide.

I also feel that Dr. McCall's satisfaction with present progress is commendable, but does not go quite far enough. He gave me the impression that there was a definite beginning and a definite ending to the obligation of the dentist to the community, and at that ending the obligation of the medical man was assumed. In other words, it was a fairly clear-cut definition between the duties, assumed or otherwise, of the two professions. I cannot agree with that view, although I recognize that my opinion may well be wrong. Certainly there is overlapping; there is no beginning or no ending to medicine or dentistry as far as the mouth is concerned.

Alfred Owre, D.M.D., M.D., C.M., B.A., Sc.D. (New York City): We may not believe in the League of Nations, but I believe in a group like this, where we can talk things over freely. It is most important that we have these discussions, no matter what conflicting opinions may be presented. Although I heartily approve of the American Board of Stomatology, it is not at all my exclusive creation, and it has nothing to do with the educational program at Columbia. The universities are able to take care of themselves. (By universities I mean, of course, the comparatively few real universities.) Dr. Dunning brought out that it is necessary to have some kind of certification for all specialists. In most of the medical meetings I go to (and I attend quite a number), I hear much talk on this necessity for the certification of specialists. A proposal to certify stomatologists is of course simply along the same line. Whether it is done by one accredited authoritative agency or another matters little, so long as the public is given the means to learn whether it is in the hands of competent specialists.

I think Dr. Dunning's definition of stomatology and the stomatologist exceptionally fine and well taken. But I disagree with his statement that no action of this kind should be taken without the approval of organized dentistry and organized medicine, for I believe we should never get the approval of organized dentistry. It is today in the hands of the well-organized minority. You might call it a vested interest. Dental education is regarded as a pretty good business in some quarters. Dental educators often make "big money." Of course, you cannot expect a distinterested viewpoint from a man with a large income from proprietary dental education. I think Dr. Dunning's summary of the whole situation was excellent.

Dr. McCall spoke of the legal status of dentistry. I wonder if we might not interject the idea of the university status of dentistry as something to think about. You can get legal recognition for a "profession" almost any

time in a democracy. Take France, for instance, where, as you know, a vested interest can preserve itself through a small minority in the Chamber, sometimes only one member. Look at the recent discussions in the French Academy of Medicine! The vested interests of dentistry of course won out, though not by "an overwhelming majority." They did preserve their autonomous status for a while longer. Dr. McCall refers to us as a profession. Yet one of the finest recent books on education—Dr. Abram Flexner's "Universities: American, English, German"—does not class dentistry as a profession; rather as something that does not belong in the university. You all know I am an ardent advocate of making dentistry a profession worthy in every sense of university affiliation. But with its present standing one of the greatest authorities in education does not so recognize it. Scientific comment is generally in agreement with Dr. Flexner. Why are we not a profession? Many dental practitioners and writers refer frankly to dentistry as a business. Can we justly lay claim to being a profession as well? Further, I doubt very much whether we have the general approval of medical educators. (There are some such educators who dislike to see dentistry disturbed for financial reasons.) Dr. McCall quoted Dean Marriott of the Medical School of Washington University as approving of dentistry as it is. Yet one of the dental teachers in the same university quite emphatically disagrees with Dean Marriott.

Dr. McCall drew attention to the fact that our major interest is in biology, and stated that we would carry on researches in biology if we had the funds. Here is the crux of the situation. Dental schools have not the funds; those who are able to give the money are not giving it very fast. Why? I do not know of many dental institutions that have been endowed as such. I do know of several that have been refused money for research projects by one of the leading foundations because of an unconvincing set-up. If some of the so-called university dental schools were to go now to the various foundations with requests for research aid in the biological sciences, I know what the answers would be. Let's be honest about these things. Some requests have been refused *because* of the status of dentistry.

The discontinuance of the Section on Stomatology by the American Medical Association was also mentioned. I was sorry to see that section dropped. The political strength of dentistry was the real factor in that action. The medical profession was confused and discouraged. Medical educators, too, have been confused by the situation. Some of the leading universities with medical schools are without dental schools. Why? Because they don't know exactly what to do. They need dentistry in some

form, but they want a logical program. It is illuminating to note what is being done at Yale University. May I read a quotation from Dean Winternitz' last annual report?

"The activities at Yale in respect to dentistry as a specialty of medicine are attracting wide interest. It is perhaps not too much to say that the concept with which this work was instituted some two and one-half years ago and for which the Rockefeller Foundation made a grant of $125,000 covering a five-year period has grown, and that plans have now been made with the approval of dentists and physicians for significant enlargement of the original plan. This larger plan will in no way immediately dislodge the current methods in the education of dentists or create invidious distinctions between existing professional groups and technical associates. It aims gradually to incorporate in medical education at Yale the teaching of dentistry from the viewpoint of the interrelationship of the teeth and the rest of the organism in health and in disease. It aims further so to correlate teaching, investigation, and practice in regard to the teeth, with the other activities of the educational service-units of the School of Medicine and affiliated institutions, that at Yale at least, dentistry will become as significant a branch of medicine as any other specialty."

Things are moving along elsewhere. In Vienna the citizens' health is now better cared for than ever before. It was found that unsupervised technicians were not furnishing very good dentistry. Now the teaching of the art of dentistry has been reorganized. All practitioners of the art of dentistry must be certified by an Institute of the University Hospital. Stomatologists are educated by the M.D. route; but if they wish to practise the *art* of dentistry, they too must be certified by the Institute. In Sweden a short time ago the inspector for dentistry recommended to the Crown that every man practising dentistry after a certain date be required to have the medical degree. The discussions in the French Academy of Medicine already mentioned (now hailed as a victory for organized dentistry) have another aspect. It was brought out plainly that some members of the medical profession in France find the present status of dentistry far from satisfactory. In their opinion dentists are unfitted to treat the pathological conditions with which they often need to deal. The mere introduction there of a strongly supported resolution to make dentistry a specialty in medicine is very significant. Proponents of the resolution went so far as to discuss various means to enable French dentists to become doctors of medicine. I was just reminded by my friend on the right that five years ago, at a meeting of one of the New York dental fraternities, I mentioned such a possibility as a dream for the future in this country.

I wonder if we are not fighting windmills—setting up men of straw in order to knock them down? Haven't we all one common interest—to elevate dentistry to a profession worthy of university affiliation? Dr.

Walker objected to the influence of extraneous bodies, such as the proposed Board, on dental education. But we already have a number of extraneous bodies dictating what they think dental education should be. I wonder if we could not safely leave it to the universities, the great universities of this country and Europe. It was stated that dental education is broadening and improving. But is it? One of the so-called university schools offers a four-year course in dentistry on top of one years' academic preparation. Several of its students made up their minds a while ago that they ought to have the medical degree, but they found they could get no credit for their four years' dental work in the medical school of the same university. This is very disheartening. In another institution, a student who had spent six years after high school getting a dental degree made up his mind to become more proficient before starting to practise. He applied to the medical school of the same university and found he could get only one year of *premedical* credit. He would have had to spend five years more to complete the work in medicine. There is your "progress." Something must be wrong with even the improved education. Three years ago, eleven students called on me. They had spent two years in one of the large dental schools of this country. Then they had learned that after graduating from that institution they would not be permitted to take the New York examinations. In the dental school they had been led to believe that they had two years of academic credit. When they applied at Columbia, however, they found they had forty points, not sixty. (It takes seventy-two to enter Columbia.) They would have had to spend approximately five more academic years to graduate in dentistry. Is this progress?

I don't think it will matter in the long run what action is taken with regard to the American Board of Stomatology. Enough of the important universities have decided to do something with dentistry, or stomatology, or odontology (it is of little consequence what it is called), when they have duly studied it, to assure us that in time the situation will change for the better. Last week at the New Orleans meeting of the Association of American Medical Colleges, at least fifteen men from medical schools in institutions without dental schools talked with me about this. We all agreed that very soon medical and dental educators must discuss jointly what is to be the future of dentistry. One dean said: "We have had about half a million appropriated for a new dentistry building, but the medical faculty is not in a hurry to perpetuate educational errors in brick and mortar."

I rather think that in the self-congratulations so often heard on what dentistry has done, we ought to incorporate an apology for the unfit, and whoever created them. We can rightly congratulate the small minority,

that group of men who have made the best in American dentistry something we can all admire. But the large mass of the unfit is a liability. If the American Board of Stomatology can hasten the university movement for better standards, we should all welcome it. I appreciate the opportunity to discuss this question. I realize that sometimes I have had to verge on the disagreeable; for this I apologize.

Henry S. Dunning, D.D.S., M.D., B.S., F.A.C.S.(New York City): I don't want to be egotistical, but probably I have worked with medicine and dentistry as much as any man in this room. I have worked in hospitals and clinics for twenty-five years, and have taught medical students and dental students. I feel that the "no-man's-land" that was talked about tonight is a very definite territory. We can't camouflage it. There is a gap between medicine and dentistry. Any oral surgeon who extracts a tooth or removes a buried third molar, and gets a peritonsillar abscess, which I have done several times—and the family calls in a physician to take over the case—feels there is a big gap between medicine and dentistry. I don't think there is a man in this audience who hasn't had that kind of experience. I don't believe that stomatology, or the American Board of Stomatology, or the practice of stomatology, is going to confuse anything. It has no legal status. What we are trying to do is to uplift and make the dental man something more than the old accepted dentist, the man who does restorative work. "Mouth physician," I think, is a very good term—"expert in the mouth," "mouth diagnostician," "oral practitioner," or whatever you want to call it. We stomatologists have no legal status. We want to get the dentist and the medical man to feel that there is a specialty here of some sort—a calling that brings us together in the little cavity called the oral or buccal cavity.

I am glad that the Section on Stomatology that existed in the American Medical Association for forty-four years (1881–1925) was mentioned. I happened to be chairman of that Section for one year. It died because of lack of dental interest and on account, as Dr. Owre says, of "politics." It was very hard to get dental men to go to the Section's meetings, and the medical men didn't want to carry it. In a period of inadvertence another section was slipped in. Why go back to that, and why say there isn't any such thing as a specialty of stomatology? "Stomatology" may be vague, but it is a profession, I think, or a practice of a specialty that the physician and the dentist ought to be interested in. There is something there, some bond, that calls together mouth practitioners that I think will promote and increase the work of the dentist. We are not trying to interfere with any dentist at all.

We have heard a good deal about how dentistry has improved; it has improved a lot. Today dentists are doing a better type of work. They know more about pathology of the mouth than they ever did before. I think we are going along the right lines. But it falls to my lot to see many scrapings, and many particles of pathological tissue, removed by dental men without any thought at all of putting them under the microscope. Dr. Cahn and others at our Medical Center, and at various places, and I, can recall a number of fatal cases resulting from lack of desire to find out what kind of a tissue the cyst contained, or what sort of a cyst or neoplasm it was. I can mention several cases that have proved fatal because of the dentist's lack of training in pathology.

By establishing this Board we are just trying to help the dentist to qualify, and to elevate the practice of mouth pathology. There will be no legal powers in the Board. We are not going to look into the colleges and boards. I think sub-section 7 of the "certificate of incorporation" was unfortunately worded.[13] We are just going to help the practice of oral medicine, if we ever get to it, which I doubt very much. We will try to get together 150 men throughout the United States and Canada who are engaged in the practice of a specialty of medicine—stomatology, diseases of the oral cavity, or whatever you want to call it—to hold meetings and give postgraduate instruction.

William W. Carter, M.D., F.A.C.S. (*New York City*): I came here to learn. Several impressions have made very slight dents in my mind and haven't yet been matured, and so I don't feel that I can discuss this important subject. Certainly it is one of very great interest not only to the dentist, but also to the physician, to the otolaryngologist. I had the pleasure of the friendship of the late Dr. Loeb of St. Louis, who was one of the founders of the American Board of Otolaryngology. I had several conversations with him before that Board was formed. He told me of many of the difficulties that were encountered and that he felt those difficulties would be very hard to overcome. They were overcome and the American Board of Otolaryngology was formed. I hope it will be of great benefit in our specialty, but as yet I haven't seen any very great advantage from it. It is an entering wedge. I believe it will place my own specialty, otolaryngology, on a very much higher plane. There is certainly a great demand for a distinctive line to be drawn between the man who can do otolaryngology and the man who can't. It seems to me that this line can

[13] Sub-section 7 of the "certificate of incorporation" for the proposed American Board of Stomatology is quoted in footnote 10, p. 22.

be drawn best by having a board that recognizes a certain man as being able to do this work. The present arrangement of the American Board of Otolaryngology is to have examinations at stated intervals. A man must not only pass this examination, but he must give evidence that he has had considerable experience in this field of work. I believe that eventually it will be a matter of great hazard for a man to attempt to do a mastoid, or any of the major operations in otolaryngology, if he has not been passed upon by this Board.

The desirability of an American Board of Stomatology is a matter I really don't know anything about. There is one thing that I have been listening for, but haven't caught as yet. I wanted to obtain a clear idea of the distinction between the dentist and the stomatologist. I don't know just exactly what is the difference between them. My belief is that the dentist's education should be enlarged to cover stomatology. I think that a dentist should be a stomatologist. Of course, we are getting down to hair-splitting when in a cavity as small as the mouth we divide into two specialties, a dentist on one side and a stomatologist on the other. One can't work without the other. I believe that an otolaryngologist cannot work to the fullest advantage without the coöperation of the dentist. I think that there should be a very, very close intercommunication between the ideas and the technic of the dentist and of the laryngologist. When some patients come to me, I can't see exactly how I can get the very best results without the advantage of having either the dentist take part in the operation that I have to perform, or at least to be near at hand so that I can profit by his advice.

Dudley C. Hughes, D.D.S. (New York City): I would like to ask: How is it proposed to give postgraduate instruction? How will an American Board of Stomatology accomplish this?

Dr. W. B. Dunning: The plan would be to formulate a certain outline of postgraduate work, and suggest it to university authorities and with their coöperation perfect such courses. It is more recommendatory at first than otherwise, and will undoubtedly involve some "trial and error." It would have to be evolved. At this moment it would be very difficult to answer the question exactly, for the working plan would have to follow many conferences before such courses could be developed in a way to make them broadly useful.

I have but one additional remark to make. I believe it was Dr. McCall who dwelt somewhat on the assumption that this specialty does not yet

exist and that, therefore, the creation of the Board is untimely. I think that that is highly debatable, and contend that the time has come for the recognition of the "stomatologist," and that a beginning should be made. With all the faults and uncertainties of our proposition, I believe, nevertheless, it contains the germs of thought and of good sense; and that after due discussion by organized bodies, both dental and medical, some plan can be worked out that will improve the present condition of things. That improvement will not be achieved except through organized effort.

Dr. McCall (*in conclusion*): I wish to express my appreciation of the very kind treatment that I have received. It has not been a gracious task to express myself as I have on this subject. I have done it, as I said at the beginning, out of a sense of conviction that this thing was not being approached in the right manner. I wish to thank Dr. Dunning for the remarks he has just made, and to say to him and to all that I too feel that things need to be improved. As I said in my paper, I did not feel that the formation of the proposed Board, at the present time at least, was the right method of approach. If this discussion starts something that may be more direct, more in keeping with a desirable trend of events in that direction, I shall be most happy. I feel that all of the discussion at this meeting has been very valuable.

[*Editor's Note.*—A statement about the public hearing on the proposed American Board of Stomatology, before the New York State Board of Dental Examiners, December 3, 1931, was published on pages 76 and 77 of the issue of the *New York Journal of Dentistry* for February, 1932.]

SOME PHASES OF HEALTH-INSURANCE TRENDS IN THEIR RELATION TO THE DENTAL PROFESSION[1]

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I. INTRODUCTION

Why do we consider it important enough to spend an evening out of our busy lives to discuss compulsory health insurance, a subject which a majority of both the medical and dental professions look upon with disfavor? Dr. Ray Lyman Wilbur, in an article in the *Sunday Star*, February 15, 1931, speaks of "the undoubted fact that most American physicians are opposed to compulsory health insurance, and they would accept it only if there were no other way of delivering adequate medical service to all the people." According to a recent survey of dentists, there was an overwhelming vote against so-called "panel dentistry." Many ask the question: Why agitate about health insurance; why

[1] Read at a meeting of the New York Academy of Dentistry, Yale Club, New York City, October 13, 1931.

talk about it? If we keep still and do not talk about it, others will not and then we will not have to face it; or as some might say, let us keep still and wait until somebody else talks about it—wait until somebody presents a bill to the legislature, then our legislative committee can tell us what to do, and we can "get busy" and prevent its adoption. One reason for not taking this attitude of indifference is that we are warned against it by the medical and dental organizations of many countries now having a system of health insurance. Nearly all such professional organizations tried that method, ignoring the subject until it was too late. All of them now regret it, and many of them have officially stated that such inaction was largely responsible for the handicaps under which the health-service professions in many countries now suffer.

Because I have not the time for a full discussion, I will not elaborate in this paper on the fact that only 20 to 25 percent of the population receive adequate dental care. For the same reason I will not elaborate on the responsibility that rests on the dental profession to meet the needs of the other 75 to 80 percent of the population. I have covered this phase in a former paper.

II. CONTEMPORARY STUDIES

The Committee on the Costs of Medical Care[2] has set itself the solution of the problem of "the delivery of adequate medical service to all the people, rich and poor, at a cost that can be reasonably met by them in their respective stations of life." Many studies have been made and facts disclosed. Many different plans of delivering medical service have been thought of and discussed by the members of the Committee. One of the schemes that is mentioned often is some system of insurance. The dental members of the Committee did not know anything about insurance practice. Our journals had few articles on that subject, so it was decided to go to the medical journals for information. There was practically no detailed information there; none that would enable the dental members to discuss the subject intelligently when the Committee finally sat down at the round table to draw conclusions and present recommendations to

[2] Dr. Phillips is one of the members representing dentistry.—[*Ed.*]

the American people. The dental members discussed their dilemma of ignorance with other members of the profession, and finally the American College of Dentists said in effect: "You certainly will need information in regard to health insurance, and we do not want the dental profession to sit dumb on that Committee. We will provide the money for a study of health insurance. We can then get the facts as to what the professions in other countries think of insurance, how it affects them and how it affects the health of the people." With the money thus provided, a search of the libraries was made and information secured.[3] Three men went to Europe this summer to make an intensive field study to check the library study, and their report will be published early in 1932.

Hardly had the announcement been given out that a study of health insurance was to be made from a professional viewpoint, when a letter was received from a large insurance company conveying the information that they were undertaking a very extensive study of the same subject—and could we not get together and plan for a coöperative study? We next received the first volume of a study of European health insurance and allied medical services, conducted under the auspices of the Milbank Memorial Fund. The author, Sir Arthur Newsholme, one of the distinguished physicians of Great Britain, spent several years collecting data on the subject and will follow the first volume with three others. This study was made for the benefit of the American public. We then learned that a study was being carried on by the Bureau of Economic Research, covering the health insurance systems already established in the United States. All these studies will be available to the Committee on the Costs of Medical Care before they formulate their recommendations for the American public.

We became sensitized to the words "health insurance," and looked over every article where the words appeared. We found that they appeared often in newspapers and magazines, and in medical and dental journals. The American Medical Association issued a handbook on the subject. Dr. Rappleye read a paper, concerning his investigations of health insurance in Europe, before a meeting of the

[3] This study was conducted by Dr. Phillips and collaborators under the auspices of the American College of Dentists.—[*Ed.*]

officers and editors of the state medical societies. "Panel dentistry" appears often in dental journals. Dr. C. G. Parnell, speaking before the Hospital Association of Pennsylvania, said that a system of insurance that allowed the citizens free choice of physicians would work no harm. Dr. Stewart Roberts, speaking in New Orleans, said: "Sickness insurance is in the medical air. . . . . The next ten years will probably witness a great extension of the plan of sickness insurance in this country as a method of leveling the uneven load in the annual distribution of illness." Chester Rowell, writing in the *New York Times* said: "The economic incidence of sickness will never be met until not only the doctor and the hospital . . . . are paid out of an insurance fund . . . . compulsory insurance. . . . . The scheme *does* work and most of the world has long been living under it. Why should America trail the procession?" Dr. Charles Gordon Heyd, President of the New York County Medical Society, says: "It is apparent that with our nearly 4000 members we have a sufficient clientele to seriously consider the establishment of an insurance bureau or even an insurance company." Thus, from many places comes the sound of discussion of health insurance. While I have quoted many more or less favorable to the principle of health insurance, many among the professions have written strongly against any extension of insurance in the field of medical care.

III. SOCIAL INSURANCE

Let us examine the subject of "social insurance," which includes a group of insurance schemes in a plan that aims to make secure the income, health, and old age of the worker. In this group are "workmen's-compensation insurance," "unemployment insurance," "health insurance," and "old-age pensions." The first of these is now operative in forty-four states, and many industries and governmental bodies have already adopted old age pensions. Unemployment insurance is now up for consideration. Both President Hoover and Governor Roosevelt have been studying this subject. You all know of Mr. Roosevelt's interest. An article in the *Chicago Tribune* of August 8, says: "It was considered not inconceivable that President Hoover's attitude toward unemployment insurance was taking shape today and the ground work laid for proposing legislation for the estab-

lishment of it at the next session of Congress." The same article states: "and such a measure is expected to be included among the chief demands of the Democrats." Mr. Swope of the power industries, as you remember, recently advised that industry should inaugurate unemployment insurance before the government was forced to do it instead. Sickness as well as lack of jobs causes unemployment. Therefore, sickness insurance is a part of and must be considered in any discussion of unemployment insurance. It is not at all outside the realm of probability that compulsory unemployment-insurance laws might set the pattern for later compulsory health-insurance laws. For this reason health insurance cannot be left out of the reckoning when unemployment insurance is being discussed.

In a monograph recently issued by the Metropolitan Life Insurance Company, the foreword reads as follows:

"Because of the present widespread public interest in all forms of social insurance, the Metropolitan Life Insurance Company has undertaken to make an unbiased, systematic study of the subject through its research department. It is analyzing the various voluntary and compulsory social insurance systems here and abroad, including unemployment insurance, sickness and invalidity insurance and old-age pensions. For twenty years the Metropolitan has been accumulating data on social insurance, in its endeavor to study the systems which other nations, as well as our own, have devised in their efforts to provide security for workers against the major economic risks of unemployment, sickness, invalidity, and old age. It is the hope of the Metropolitan that the factual material which it is now assembling will be of value to every one interested in the question."

In the introduction to the same monograph is the following:

"In practically all of the civilized countries today the income of the worker and his family is obtained principally from his employment, and, unless other provision be made, that income stops while he is unable to work because of sickness or invalidity. . . . . A number of the insurance plans now operating were restricted in the beginning to wage-earning groups in a limited number of occupations, but there has been a marked tendency for these plans to extend their scope, not only to all wage-earners, but likewise to salaried employees whose remuneration does not exceed a certain limit. . . . . All the national plans which have been initiated since the war are of the compulsory type. The past and present experiences of Europe

in this respect are sufficient indication that those who may be considering the advisability and practicability of a state-established sickness plan for this country are confronted with many difficult problems. Some of the general questions which will arise are: 'What plans of health insurance are now in operation?' 'Have they been accompanied by improved public health?' 'What errors and weaknesses have developed?' 'How and by whom should the plan be administered?'"

"In addition, a great many specific details will have to be considered, as for example, the following: 'Should the plan provide free medical benefits, drugs, appliances,' etc.? 'Should the plan actually provide doctors and druggists, or should it merely pay the bills of the insured?' 'What is the attitude of the medical profession, in countries with sickness insurance plans, toward free medical treatment?' 'What are the best measures to prevent doctors from being too lenient in recommending benefits or prescribing too expensive drugs, appliances,' etc.?"

How many of these questions can you answer? All of them should be thoroughly understood by the medical and dental professions before any health insurance project is introduced in any state legislature. If the health-service professions learn much about these matters, and have definite facts to present, it is highly probable that the professions affected will be called in consultation before any plans for the extension of medical care are projected. Remember that insurance carriers are interested parties, and that it would not be wise to have them furnish all the information.

I presume that, by this time, this dental audience is beginning to ask: What has all this to do with the dentist? In early insurance systems the medical care given by the physician was the first step. The extension of insurance to dental care followed immediately. In later schemes dental service has been included in the original plans, as in France. Hence it is only by studying what happened to the physicians by the introduction of insurance that we are able to understand what will happen to dentists. Let us examine for a few moments the experiences of the New York State Medical Society in its contact with insurance carriers in workmen's compensation. Most workmen's-compensation laws in the United States were imported from England, beginning in 1911, and in a few years had spread to the legislatures and law books of forty-four States. The organized medical profession had

no part in the making of these laws, and up to the present have had very little to do with their administration, yet in New York State alone the sum of from $9,000,000 to $12,000,000 is paid yearly for medical and surgical care by the insurance carriers under workmen's compensation.

The report of the President of the New York State Medical Society, in 1930–1931, shows that our professional brethren in Europe are not the only ones who are having difficulties with insurance systems that provide medical care. Thus, three of the important committees of the New York State Medical Society have been wrestling with the problem of how to get along with workmen's-compensation insurance-carriers. These committees are the Public Relations Committee, the Committee on Medical Economics, and the Committee on Legislation. The *Public Relations Committee* says: "It will seek a conference with representatives of federated labor, for the purpose of discussing with the leaders of that large organization the function of the physician in the administration of the workmen's-compensation law. Insurance carriers and proprietors of industries, physicians have contended for some time, frequently are not sympathetic with the physician's efforts at rehabilitation." The *Committee on Medical Economics* states: "The Committee after deliberation felt that matters incident to the medical and surgical care of the employees in connection with the workmen's-compensation law were most pressing, and the greater part of its time was spent on this matter." To meet the pressing need, the Economic Committee formulated and proposed certain principles and agreements on which county medical societies and insurance carriers might agree. The proposed agreements were designated primarily to secure a means whereby the family physician and general practitioner may treat compensation cases without authorization (the free-choice-of-doctor principle). In order to secure recognition of this principle by the insurance carriers, the physicians are to agree as follows: to work toward the end that the employee be brought back as quickly as possible to an economic and efficient person; to impress on its members the need for filling out the necessary papers; to furnish such information as the physician has when filling out the form, and to furnish such other reasonable supplementary information as requested; to evolve from time to time fee schedules; to seek advice and abide by decisions

of the carriers in respect to consultation, x-rays, physical therapy, and other treatments beyond ordinary treatments. On the side of the insurance carriers they agree among other things to furnish such literature as may be available, and to take other measures to aid in instructing members of the County Medical Society in relation to the industrial, medical and surgical fields. The medical profession of every insurance country in Europe consider some points vital to the protection of their interests as well as the interests of the patients they serve. From the standpoint of the insurance carriers the object of medical care is the restoration of the patient to *work* instead of to *health*. They demand that permission be given to them to fix all forms of reports. This permission the physicians contend would concede points of professional secrecy, would overburden the physician, and would place the carrier in possession of all the material information needed in subsequent conflicts, while the profession would lack such information. The agreement would lead to fixing a fee-schedule by bargaining, when experience has shown that in the long run the carrier is far better equipped for collective bargaining than a professional association. It would permit "lay control" of medical treatment and insurance carriers to "educate" the profession along the lines of industrial medicine and surgery.

Consider some phases of the report of the *Legislative Committee*. They report "several bills providing for free choice of medical care by the injured workman were introduced, but all met the same fate; they were killed in the Labor Committee." Before speaking of another statement in the report of the Legislative Committee, I wish to refer to some advice given by Dr. Alfred Cox, Secretary of the British Medical Association. He advised the professions in America to "get in on the ground floor," and have a voice in the making of any laws relating to medical care. Once the laws are passed, the pattern of administration is fixed. The result is that the organized profession on the outside is forced to become a mendicant seeking favors from politicians who may or may not grant the favors requested. The following quotation from the report of the Legislative Committee indicates that the medical profession in New York is unfortunately on the outside:

"Acting as directed by your body last year, we, through the Executive Officer, sought a conference with the Commissioner of Labor, for the purpose of redrafting the bill providing for the creation of a medical advisory council

in the Department of Labor, but met with indifferent success. We wrote to the Commissioner on November eighth, asking for a conference, but received no reply. We spoke with her twice on the telephone and finally called upon her when she was in the Capitol. She frankly stated that she did not want a medical advisory council created, and suggested that the matter be brought before the commission appointed by the Governor to review medical and surgical problems in connection with the workmen's-compensation law. Realizing that no bill could pass if she opposed it, we accepted her suggestion."

IV. RECAPITULATION

(1) The health-service professions in America are opposed to compulsory health-insurance schemes.

(2) European leaders advise intelligent professional understanding and direction of insurance schemes if such are proposed.

(3) American insurance companies and funds have collected a vast amount of information on health insurance, and are ready if it should be proposed.

(4) American medical and dental journals have not up to the present collected or presented any volume of authentic information on the subject.

(5) Many newspapers, magazines, individuals, and organizations are discussing health insurance.

(6) Health insurance is one of the parts of the general scheme of social insurance as is workmen's compensation.

(7) Workmen's-compensation laws imported from England are in force in many states.

(8) Industrialists and politicians (or statesmen) are studying European unemployment-insurance. Some recommend it.

(9) Unemployment-insurance schemes must consider the unemployment phase of sickness and invalidity.

(10) Because it did not "get in on the ground floor," the medical profession in the state of New York is in the position of a mendicant begging for favors from insurance carriers and politicians.

(11) What happens to the medical profession generally happens later to the dental profession. I quote from an article by Dr. Heyd:

"Any system that concerns itself with medical care must bear in mind that the fundamental conception is the quality of medical care and not the scheme

of organization or its financial background, and any plan, whether devised by doctors themselves or imposed upon the medical profession from outside sources that diminishes the qualifications for competent medical attention upon the part of the physician in the care of his patient, is in the long run detrimental."

V. SOURCES OF INFORMATION

Before discussing in detail some of the different insurance schemes in Europe, I shall point out the sources from which information is secured, and appraise the value of each source as given by our investigators.

Official government reports. These are prepared by and express the attitude of official bureaucracies and civil administrators, who, in turn, are swayed by contending and changing political forces. Naturally, official documents try to dodge the political results that follow the publication of controversial facts, but insurance is born out of and lives in the midst of a host of sharp controversies, every one of which has political expressions.

Publications of insurance Funds (approved societies, Krankenkassen, caisses, insurance funds). These with some exceptions manage most of the phases of insurance. Their publications seek constantly to prove the efficiency of their administration. One of their largest and most flexible items of expense is composed of the fees paid to physicians and dentists. The burden of their argument is that if the Funds only had a more complete control over medical service, all the evils could be abolished.

Publications of the medical profession. These publications present the viewpoint of the professions in Europe. In countries having health-insurance systems from 40 to 80 percent of all medical work is done for the insured population and under insurance regulations. This work is done exclusively for the low-income classes. To gain an idea of the change worked by insurance, contrast this with the situation in the United States, where it has been estimated that only 20 percent of the population, and this the most highly paid class, receive adequate dental care. Practically every phase of the lives of physicians and dentists is profoundly altered by such a change. The first reaction is the natural one, common to all human beings—to resist

change. A second reaction is the equally human one of a desire to secure as large a financial reward as possible. The third combines the universal resistance to restraint of any kind, with the professional knowledge that such restraint in this field produces peculiarly virulent evils, and finds its expression in the bitter battle against "lay control." These reactions cause professional statements in insurance countries to put great emphasis upon "free choice of practitioners," "professional secrecy," "direct payment," and opposition to clinics.

Statements of observers and critics. Most observers and critics adopt one of the views already indicated. This is true of official investigations. The exceedingly valuable and elaborate studies of the International Bureau of Labor are perhaps the most important single source of information on health insurance, and are usually accepted as adequate and unbiased. But very important is the fact that the International Labor Board, by the vote of an overwhelming majority of its constituent nations, has been instructed actively to propagandize for the extension of such systems to non-insurance countries.

VI. FEATURES OF SOME PRESENT SYSTEMS

Germany first established compulsory health-insurance, and has recently celebrated a half-century's existence of the system. Many later systems followed the German pattern. The latter has changed so frequently that the copies differ. Year by year new classes have been included and new benefits given. Today more than 40,000,000 persons come within the scope of German health-insurance. Of the German medical profession, 80 percent work almost exclusively in insurance practice; 15 percent are salaried employees. Private practice is no longer considered in measuring the opportunities of the newly graduated physician or dentist. With most of the population entitled to medical care, including the services of general practitioners, surgeons, dentists, specialists, hospitals, sanitariums, convalescent homes, and all manner of "cures," recent writers estimate that about 30 percent of the medical care of the German people is given by quacks, and paid for in cash. This looks like general dissatisfaction with insurance service. But quacks do not flourish so extensively in all insurance systems, and "cults" and irregular practitioners are not unknown in the United States. It is at least a safe conclusion to say

that even practically unlimited free medical service would not abolish quackery.

The fact that medical compensation is fixed by bargaining between the Funds and the professions has led to the formation of "economic organizations" in the professions. These perform all the functions of trade unions, including the conduct of strikes. There have been frequent secessions, and underbidding by factions of the professions, which as in the industrial field are known as "yellow unions." Legally the physician is unrestricted in the right of prescribing. Actually he is closely supervised to compel adherence to an average cost of drugs. The recent "emergency decree" put teeth in this regulation by making it possible to disqualify a physician for insurance practice if he repeatedly ignores warnings as to "economical prescribing."

VII. DENTISTRY UNDER GERMAN INSURANCE

In Germany, dentistry was so little developed fifty years ago that it was given scant notice in the original organization of German insurance. It came into the scheme under a regulation permitting the attending physician to order any dental work needed to restore the patient to *working efficiency*. This attitude still dominates in spite of a half century's changes. *In fact the real object of all medical treatment under insurance is to restore working capacity rather than to cure the disease.* In dentistry this has caused an over-emphasis on dentures and a neglect of preventive work. The managers of the insurance societies say: "We cannot afford to spend money on bridges and fillings, only to have to pay again next year for taking out and replacing the repaired teeth." The peculiarly divided evolution of the dental profession in Germany has made it difficult to establish and maintain any policy in opposition to the insurance societies. When insurance was introduced dentistry was primarily a luxury practice, conducted by the Zahnärzten. These are "stomatologists," i.e. physicians with special dental training. What little care the working class received was largely given by unlicensed practitioners and dental technicians. The Zahnärzten were few in number and located so exclusively in the great cities that the insurance societies early claimed that it was impossible to confine dental practice to them. To meet this situation the governmental insurance department (*Reichsversicher-*

ungsordnung) issued a very famous regulation which has dominated the dental side of insurance ever since. This regulation provided that in case of emergency or when no Zahnarzt is available, if the patient agreed, dental work might be done by dental technicians. This regulation proved the entering wedge of a policy that enabled the insurance societies to hire dental technicians at a lower cost than would be required for the services of Zahnärzten to do most of the required dental work. So encouraged, the dental technicians adopted from English and American practice the *title* of "Dentist," established their own schools, and became the dominant element in insurance practice. The result was another bitter inter-professional quarrel, and recriminating underbidding for insurance practice, which has reduced the income of the entire profession.

Clinics are still a subject of bitter discussion in German insurance practice. Many of the societies established clinics as weapons in the midst of conflicts over terms of service, sometimes as a means of breaking dental strikes. Dental spokesmen charge that some at least of these clinics not only are used to force down fees in insurance practice, but also invade the field of private practice to the injury of the few private practitioners that remain. The whole matter is too largely controversial for firm conclusions, but the claim is quite generally made that dental clinics are proving less efficient and economical than was expected. An official of the Ortskrankenkassen of Leipzig, in showing the deserted clinics in the headquarters of that society, stated that the clinic had been abandoned because individual practitioners gave cheaper and more satisfactory service. This society is one of the few that employs practically none but Zahnärzten, and seems to enjoy good relations with the dental profession. The above statements do not refer to the dental clinics in Vienna, where they seem to give satisfaction. The number of Zahnärzten has increased rapidly in recent years, and they are now demanding that they be given exclusive control of insurance practice, and that the "Dentisten" (dental technicians) be permitted to practice only under the direction of Zahnärzten. The latter claim that the training given in the recently established colleges of dentistry is chiefly of a mechanical nature, and weak in basic sciences and biological subjects.

Whenever under insurance a health-service profession becomes

overcrowded, the problem of elimination is quite different from that in private practice. In the latter system competition eliminates those unable to secure patients. Under insurance, all new graduates are excluded until their waiting period has expired, and then are admitted according to definite regulations.

VIII. HEALTH INSURANCE IN GREAT BRITAIN

While most of the continental systems of Central Europe followed the German model more or less closely, that adopted by Great Britain in 1911 differed in some very fundamental respects. These differences seem to indicate an evolution that is taking place in the attitude toward some of these features. The most fundamental change is found in the fact that the separation between the administration of cash- and service-benefits is much wider and more definite than in the German system. The original law placed the physicians under the direction of the "Approved Societies," but the British Medical Association declared that its members would not serve under such a system. As a result of this action the medical service was placed directly under the Ministry of Health. Its pay is fixed and discipline enforced almost entirely independent of the Approved Societies. These societies are fraternal organizations, mutual insurance societies, trade unions, insurance companies and similar bodies, most of which had been engaged in some form of private health-insurance previous to the enactment of compulsory insurance. They were sufficiently powerful to have great influence in the legislation creating the scheme, and to control most phases of its administration. Today there is a strong and growing feeling in Great Britain that these societies are largely unnecessary cogs in the machine that might be eliminated with advantage. Nevertheless, they are so strongly entrenched and have so great an influence in so many directions, especially in politics, that there is little prospect of their early elimination.

Every registered physician can enter insurance service by merely expressing his desire to do so. His name is then placed on the list of insurance practitioners in his district, and he is required in his insurance practice to conform to the regulations of the system. This list is posted in the local postoffice where it is known as the local "panel." This is the origin of the term "panel dentistry." Just to clear up the

misuse of this phrase it may be said that there is no "panel practice" outside of Great Britain, and that the term applies only to physicians in that country. There is no such thing as a dental panel or "panel dentistry" anywhere, because no country has such a posted list of dentists. In theory the physicians have absolute freedom of practice, and any insured person is entirely free to choose any physician "on the panel." In practice the Regional Medical Officers exercise a close, though tactful, control over medical practice. They are employed directly by the Ministry of Health and follow up complaints by patients or societies. They also check upon the economical prescribing and, most important of all, are the court of appeal on the granting of incapacity certificates. Perhaps because of their tact, their freedom from control by the societies, and the fact that no serious disciplinary action is taken without the presence and advice of a representative of the British Medical Association, there has never been so bitter a conflict between societies and practitioners in Great Britain as that existing in Germany. Nominally the societies are absolute judges as to whether cash relief shall be granted. In practice they usually accept the physician's certificate, thereby shifting the responsibility to him, and then blame him bitterly for what they claim is excessive complacence in granting the certificates. There seems to be general agreement among the members of the British Medical Association that the average British insurance practitioners are receiving more money than most physicians with a working-class practice received before insurance. The British Medical Association has been very actively and intelligently "on the job," to protect the interests of its members ever since the law went into effect, although it admits that unpreparedness at the start caused much subsequent trouble, conflict, and discomfort.

IX. DENTISTRY IN THE BRITISH SYSTEM

Dentistry came into the British insurance system by a side entrance, and subject to the machinery already established, in the construction of which the dental profession had little voice. The British system provides only for such medical care as a general practitioner is competent to give, and does not include the service of specialists or dentists. In the effort to encourage competition in efficient management between the different societies, the law provided that any surplus that appeared

as a result of a five-year audit could be used by the society for "additional benefits," which became the favorite arguments of the societies to attract new members. These benefits may consist of additional cash payments, optical or dental service, etc. The membership quickly decided that they desired dental service more than anything else. It has, therefore, received a larger percentage of the surplus of the various societies than any other form of benefit. The dentists, like the physicians, are not required to make any contracts with the Funds. No dentist need do any insurance work unless he wishes. If a patient presents a "dental letter" from his society, stating that he is entitled to dental service, any dentist may do the work with the knowledge that he will receive payment only according to a schedule of fees fixed by the Ministry of Health in consultation with the dental organizations. There is much disagreement as to the fairness of this schedule. Many dentists who have a wide knowledge of the field declare that, when it is remembered that there are no bad debts in insurance practice, the income of the dentists mainly engaged in insurance practice is as high or higher than that of the dentists in working-class practice before the days of insurance. Others declare that because the insurance fee-schedule is lower than that usually charged in private practice, and since it is difficult for a dentist to maintain a schedule for his private practice higher than that paid by his insurance patients, the result has been to lower dental incomes in working-class neighborhoods.

The dentists are under the supervision of Regional Dental Officers. Perhaps because it is generally agreed that in the beginning these Regional Dental Officers lacked the tact of the Regional Medical Officers, or perhaps because differences in opinion as to dental treatment are especially aggravating, there was considerable friction between the Regional Dental Officers and the practising dentists. Many of the societies refer nearly every estimate of the practising dentists to the Regional Dental Officer for criticism. Practitioners claim that the Regional Dental Officers, anxious to show their authority and justify their existence, were captious in their criticisms and altered estimates and changed treatments without justification. It is also a frequent charge that the $200,000 expended annually for Regional Dental Officers would produce much better results if added to the decidedly

inadequate funds for dental treatment. The general attitude of English dentists to insurance may be judged by the fact that, before the end of the first five-year period, the British Dental Association began an agitation to have insurance extended to dentistry. It even went so far as to set up model organizations where insurance patients were treated. It also made a very thorough study of the subject, and from the beginning the British dentists have been well organized, alert to their interests, and have exercised a great influence in determining the place of dentistry in the insurance system. It was difficult to do this because British dentistry is divided. Prior to 1921 there was "freedom of practice" in the field of dentistry. The British Dental Association, which consists of graduates in dentistry of reputable colleges, secured the passage of a law setting up definite standards of education for admission to the profession. This law went into effect in 1921. In order to make provision for the large number of unqualified practitioners who had spent many years in this field, it was provided that all those who had been practising dentistry for a certain period before 1921 should be admitted to the register. In the beginning there was considerable jealousy between the two classes of practitioners, which resulted in the formation of several rival organizations. These organizations now coöperate in insurance matters, and all are represented on the committee with which the insurance administration deals. The standards of remuneration that prevailed before 1921, however, had established correspondingly low fees. This fact must be borne in mind when comparing fee schedules for insurance practice with those prevailing in America. It is much fairer to compare them with the fees which existed prior to the introduction of insurance.

British dentists have led the way in practically all matters concerning the practice of dentistry under the insurance act. They have prepared plans for future action, discussed them in their journals and association meetings, instituted investigations of specific problems, secured representation upon governmental bodies, and obtained a large percentage of their objectives. At the present time they are discussing a "plan for a national dental service," developed to coöperate with a similar plan for a national health-service proposed by the British Medical Association. Neither of these plans has any prospect of adoption in the immediate future, but it is quite certain that what-

ever evolution takes place in the care of the health of the British population will follow the pattern of those plans.

It is difficult to judge the service given under insurance. It differs widely under dissimilar circumstances as it does under private practice. The British insurance dentist almost always has both private and insurance patients. The regulations are very strict in insisting that no discrimination be made. But there are many limitations on the character of insurance dentistry. The Approved Societies seldom approve the use of precious metals. There is undoubtedly a tendency to liberal extractions and replacements with dentures, instead of preventive and prophylactic treatment. The fact that this tendency is alternatively denied, denounced, and deplored by insurance advocates proves its existence and also probably foretells improvements in the future. Furthermore, the service must be compared, not with ideal conditions in luxury practice, but with the service received by the same sort of low-income classes before insurance and in countries without insurance. When so compared there is almost unanimous agreement that a large number of people are receiving dental service that did not have it in pre-insurance days, and probably do not get it in non-insurance countries.

X. INSURANCE SYSTEMS OF OTHER COUNTRIES

Compulsory health-insurance is in force in twenty-six European countries, but Germany and Great Britain have been selected as the two largest systems in operation, and also because they represent somewhat widely differing types. They also seem to represent stages in an evolution that appears to be moving toward wider separation of cash- and service-benefits, and toward greater control of the service features by the professions. It is manifestly impossible within the scope of this paper to enter into any description of a large number of systems, although there is enough variety to make possible a comparison of some very vital points. This must be reserved for the complete report.

The French system, because it is the most recently adopted by a large nation, and because it seems to represent a further step in the evolution mentioned, deserves a few words. The French physicians and dentists had a larger voice in the legislation upon which the scheme is based, and in its subsequent administration, than their

colleagues in any other country. The service is completely under professional control, except for a provision for the settlement of disputes between the Funds and the physicians by impartial bodies. One feature deserves special consideration. The patient pays a share of the fees for treatment. The Funds pay a fixed percentage of an established fee schedule, but the practitioner is in no way governed by this schedule in fixing his prices. He may charge what he wishes as in private practice. It is believed that this will do away with many of the difficulties relating to the treatment of trivial illnesses, and of "neuroses" due to the desire to obtain free treatment and certificates of incapacity. While it is too early to draw any firm conclusions (the system has been in operation only about a year), there seems to be a general agreement that it is accomplishing these results.

XI. CONCLUSIONS

From this brief review of the developments in health insurance in Europe certain conclusions seem apparent. In the first place, it cannot be denied that the health-insurance systems abroad have generally brought dental care to large numbers of people who formerly received less service or no service. It appears, however, that in most countries the quality of dental service received under insurance is not what would be considered adequate in terms of modern standards. In most countries, at the outset, the attitude of the organized medical and dental professions was as a rule hostile and obstructive; but nowhere has this attitude stopped the development. In the countries where the health-service professions have assumed responsibility and control in the medical aspects of the insurance systems, there appears to be less virulent conflict within the system and less general dissatisfaction with insurance. The quality of the care rendered, and the rewards and status of the profession, have improved in proportion to the amount of responsibility given to the professions for the medical aspects of the work. Denmark, France, Great Britain, and Sweden, which of all European countries appear to be the most satisfied with their insurance systems, are also the countries from which an affirmative answer was recently received by the International Medical Association to the question: "Does the medical corps have an effec-

tive and efficient control in the organization of medical care in the home, hospitals, sanitaria and other cures?"

No statement in this paper should be construed as an endorsement or condemnation by me of the compulsory-insurance system as such. The object of my paper is to point out the relations of the health-service professions to insurance systems already developed, and the effect of professional leadership, or lack of it, on the form of the insurance system adopted. As has been pointed out in the case of German health-insurance schemes, and of the New York workmen's-compensation insurance, the medical professions feel that their interests receive small consideration. On the other hand in Denmark, England, France, Sweden, and several other countries, the organized professions are of the opinion that their interests do receive consideration.

In closing may I quote from Dr. Glenn Frank's article, "The Medical Revolution," published in the *Journal of Gynecology and Obstetrics*.

[He asks]: "Is private medicine to be superseded by state medicine or its equivalent?" [He replies]: "The answer to this question will, I think, depend on the quality of medical statesmanship displayed by the medical profession in the years immediately ahead. . . . . If the medical profession does not display adequate statesmanship in meeting social issues, it will eventually be led and administered by industries, insurance companies and governments."

XII. DISCUSSION

Michael M. Davis, Ph.D. (Chicago, Ill.): Several points that Dr. Phillips discussed come particularly within the scope of matters with which I have been more or less concerned. There are also certain points in the paper which, of course, a layman cannot discuss. It might be worth while for me to speak of some of the facts that bear upon the percentage of our population who are receiving adequate dental service. This is one kind of study which the Committee on the Costs of Medical Care has made in a survey of selected communities.[4] The City of Philadelphia, Shelby County in Indiana, San Joaquin County in California, and some other localities in the United States, have been studied rather carefully, by persons who have lived there for a period, with reference to medical facilities, physicians, dentists, hospitals, and nurses. The medical services rendered have been measured

[4] Dr. Davis is a member of the Committee.—[*Ed.*]

in terms of their amount, and the expenditure for them by the population. In San Joaquin County, California, having a population of about 100,000, the dentists, taking their combined lists of patients during the course of a year, had under treatment during that year 37 percent of the population. That includes the whole population of all ages and, of course, patients who came to dentists' offices once as patients, as well as those who were under regular attention for a number of times. That is the highest percentage in any one of the studies. In Shelby County, Indiana, considerably less well provided for in professional services than San Joaquin County, California, the proportion was about 24 percent. None of the areas studied so far have included the poorer sections of the country—the very sparsely settled sections, such as those in the South or West. Nor have they included intensive studies of the poorer sections in larger Eastern cities. It is obvious that 37 percent or 24 percent of the population receiving *some* dental attention during the year means only a smaller percentage receiving *adequate* dental attention.

Another source of evidence is based upon the number of patients recorded by dentists as being under their care. In the report of the Committee to which Dr. Phillips referred, it will be found that the average number of patients per dentist per year reported is 437. The common estimate is about 500 patients per year per dentist. If we multiplied the first figure by the number of dentists in the United States, the result would indicate that less than 30,000,000 persons per year are under the care of dentists. These figures indicate that about 24 percent of the population of the country as a whole is getting some dental attention in a given year. This means that, in the course of two or three years, a larger number of the people would get *some* dental attention. It also means that there is only a certain fraction—just what it is you can guess better than I—of the 24 percent who are receiving *adequate* dental attention. The man who came once in, say, three years, to have a tooth removed because he had a bad toothache, would be numbered in the 24 percent.

The data for expenditures is another source of evidence. Approximately 10,000 families have been studied. Their expenditures for all forms of medical service including dentistry, hospital care, nursing service, and so on, have been studied, and the data are now being worked up into a report. The average expenditure per family for dental care will probably come out something like $16 per year per family. This value is preliminary and tentative, and probably is above rather than below the actual figure, because the very poor groups are not reported. We know that approximately half the number of these families spent nothing or almost nothing in a given year for dental

care. The average of $16, therefore, includes a very large number of families who spent nothing or almost nothing for dental care, and also a group who spent fairly considerable sums and thus raised the average a good deal. Quite obviously, for any sum approximately $15 per year per family, adequate dental care at normal private rates could not possibly be furnished.

All the preceding figures can be taken in various ways, but I think we are safe in saying, as an estimate, that 20 percent of the population is receiving something approximating adequate dental service. It probably is not higher than that. What do these figures mean? We must interpret them. Does such a small proportion of the population get insufficient dental service because dentists are not available? Do they fail to get service because they cannot pay for it, or because they do not want to pay for it? In entering into a discussion of this question, I am constantly faced with the retort: "But look at all the things people spend money for." Think of the radios and automobiles—a half-billion dollars a year for candy (more than for dental service in the whole country, with perhaps an effect also on producing *need* for dental service). Half a billion dollars for candy, and more than that for radios, automobiles, silk stockings, whatever commodities you please which you may regard as luxuries! Billions of dollars spent on such things and a paltry $400,000,000 a year altogether spent in this country for dental services! Whereas, if people would only stop spending money or reduce their expenditures on these delightful luxuries, how much more adequate dental service they could obtain! The argument is conclusive. If people would do these things, they could spend more money for dental service. The argument is sound, if we may assume that it means anything practical. Why do people spend money for automobiles, candy, "movies," and such other luxuries? The answer is because they enjoy these products, because these products are widely advertised. It is almost impossible to take a copy of the *Saturday Evening Post* and read the advertisements, not to speak of the stories, and not at once go and spend all the money you can possibly get for some of the things there advertised. The advertisements are extremely interesting, and persuasive, but they ought to be. They are written by very highly paid and skillful persons. On the whole, the kinds of things advertised are the things the average person wants to get. Unfortunately, dental care is not enjoyable except to the hypochondriac, who may occasionally be found in the dental chair.

No group gets very far by trying to tell other people how they should spend their money. It may be a highly moral thing to advise them to spend their money in a certain way. Such advice rarely changes their expenditures, but rather tends to arouse a feeling that what the adviser

really wants is to get you to spend money on his particular products rather than on others. A long time ago wise merchants learned that it does not promote their business to criticise their competitors. I suggest that the argument, that people ought to spend more money for dentistry and less money for certain kinds of luxuries, had better be confined to intramural discussions, because its effect on the general public will not on the whole promote larger expenditures for dental service nor a more friendly attitude toward the dental profession. We should also remember that the members of a profession like medicine or dentistry are not those who hear most of the complaints their clients voice regarding the practices of the profession. You do not tell your complaints about medical service to your doctor. You tell them at afternoon teas to your favorite friends, or in the smoking compartment to lay friends. Therefore, it is rather difficult for a purely professional group to judge the lay attitude.

I come back to the significance of the basal fact that only a fraction of the population is receiving adequate dental service. I place beside that fact the point that we shall not change that situation by scolding the public for not spending its money as we would like to have it, even though we are quite convinced it would be to the interest of the public to do so. The fact that only a fraction of the public is receiving adequate dental service faces the dental profession with its supreme challenge. A profession has a primary obligation of service to the public. The public owes that profession in return adequate remuneration and opportunities for the maintenance of its own standards. But the profession faces, as I say, the primary obligation of service, and these facts challenge the medical and dental professions with the question: "What plans have they made or are they making to meet the situation?" The public demand for dental service is increasing. It is highly significant, as Dr. Phillips has told you, that one of the first and most popular additions to the benefits furnished abroad under insurance, as funds become available through insurance collections, is dental service. This is added voluntarily by groups of the insured persons who tax themselves extra amounts because they wish the dental benefit. There is evidence in this country, in such small experiments as have been made to provide dental services through insurance methods, that dental service is strongly desired by the beneficiaries as soon as it becomes practically available to them. Last spring, in visiting California and talking with dentists and physicians, I was impressed by the attitude of the State Medical Society. They are faced by the fact that voluntary sickness-insurance under industrial auspices is going ahead at a rapid rate. They are not opposing it, having recognized, as was brought out in Dr. Phillips' paper, that it cannot

be stopped by mere opposition. They are endeavoring to stage a demonstration in a locality where the county medical society will offer the public, in coöperation with responsible industrial and business leaders, medical service for a flat basic payment per year—that is, on an insurance basis. They will doubtless arrange coöperation with the dental profession to bring them in on the same basis. The members of the medical committee now working on this demonstration said: "We must work out some such plan as this to demonstrate to the people of California that the medical profession is itself endeavoring to move forward to meet an evident public demand, not wait to have the public force its demands upon the profession."

It is depressing to be compelled to admit the force of the points Dr. Phillips made regarding the lack of information on the subject of insurance now apparent in professional circles. In medical circles there is not merely lack of information, but a constant stream of misinformation and biased information about "state medicine" abroad. One of the leading officials of the Metropolitan Life Insurance Company remarked to me last spring that, in Germany, the amount of state participation in insurance was no greater, possibly somewhat less, than the degree of supervision exercised by the New York State Insurance Department over the Metropolitan Life Insurance Company. Insurance in Germany is not administered or contributed to by the state. It is supported by voluntary organizations of employers and employees, which may number a million people in Berlin and a few thousand in a small place. In Great Britain the state takes a larger part both financially and administratively than in Germany. In this country some forms of state medicine are moving ahead at a rapid pace, as in provision of state hospital service. Michigan has a great state-university hospital drawing patients from all over the state. It is an outstanding example of state medicine, but nobody has yet moved from Michigan to Russia in consequence, nor have people come from Russia to live in Michigan because they are attracted by state medicine. Sickness insurance abroad is, in the main, not state medicine. It is recognized by the state, sometimes required by the state, sometimes contributed to by the state, but in no country of Western Europe is it administered by the state. Misinformation is disseminated because of the lack of knowledge, and because of unsuitable selection of persons who are supposed to tell about conditions abroad. *The dental profession has undertaken a most important project in setting up, in advance of any similar enterprise by organized medicine in this country, a committee under the auspices of organized dentistry to pursue such studies as Dr. Phillips' committee has been carrying on.* The reports to be issued in the near future will have information of value to both the dental

profession and the medical profession. *It is a notable contribution that dentistry is thus making to this whole subject, and to its own standing and advancement.*

It seems to me that what lies ahead in this country is impossible to predict. There are widely dissimilar conditions in different states, and in a given state, such as those in New York City and in the rural areas of New York State. No single plan will act as a panacea for this country nor for any one state. The situation requires experimentation. We must in some fashion utilize the principle which enables people to pool their limited resources, and build up such joint funds and collective resources as are possible under insurance, thus making it possible for them jointly to purchase the services they need. The most significant single thing in Dr. Phillips' paper, so far as conclusions drawn from foreign experiences are concerned, is the fact that under insurance many millions of people in Europe are receiving dental attention who would not get it otherwise, and who did not receive it previous to insurance. Vienna has been a poverty-stricken place since the War. Dr. Sinai told me that in Vienna there were 560,000 members in the main sickness-insurance organization. He also stated that the head of this great body, and also the head of the joint medical and dental organization there representing the professional men, agreed that approximately five times as much money was spent in Vienna on medical and dental services as would have been expended if they had had a system of individual payments, because through organized payments under insurance large sums were available for medical and dental care.

I hold no brief for a particular mechanism in working toward the solution of this great problem. It is perfectly clear that the American public is intensely interested in an increase in the number of people who are to receive adequate medical and dental service. It is also perfectly obvious that an obligation rests upon the professions to work with that public, and if possible to lead them in the right direction. It is possible to move forward only by experimental methods; and these can be used to advantage only with open and scientific minds. Experiments in these matters mean trying out things that involve the practice of dentistry in conjunction with lay groups, the dentist's function being to provide the service, and that of the lay group to pay the bills and attend to those features of the organization of a non-professional character. Move forward through coöperation between the profession and the public; by experimental tests of plans adapted to American conditions, to preserve and maintain professional standards; and by operating to serve more people and to serve them better. These are present obligations that fall upon your profession.

Linsly R. Williams, M.D. (*New York City*): It has been a great pleasure to hear Dr. Phillips' discussion of health-insurance trends, which is a matter of the greatest importance. It would be impossible to discuss all the details of Dr. Phillips' paper. I shall indicate in a general way how this problem appeals to me. It seems perfectly obvious that many members of my profession are confused as to terminology. They speak glibly of "state medidine" and are opposed to it, which is probably quite right. But what is "state medicine?" I know of a county medical society that passed a resolution to the effect that the operation of a child-welfare clinic, where only advice on general hygiene was given, was not only state medicine but a menace to the public health. That does not seem to be very clear terminology. I have seen a number of definitions of state medicine—"state medicine" applies also to "state dentistry"—but I cannot see that it means anything other than that all the people of the state have the right to receive free medical and dental service given by the medical and dental professions, the physicians and dentists being employed and supervised by the state. I don't fancy that kind of an arrangement. I should like to point out, however, that in this state widows' pensions, old-age pensions, and also part of the compensation insurance, are defrayed out of taxes, and no direct contribution is made by the individual who benefits from these social measures. This is something we must note in any plan that may be formulated for extended medical and dental service in this state.

During the last fifty years there has been a very marked change in the attitude of the people of this country, particularly the thinking people, on all social problems. If you have studied the social history of this country, or if you are old enough to remember important steps in its evolution, you will recall that in 1877 and in 1893 the *first* thing done to diminish cost in industry in those years of depression was to discharge employees. *Second*, dividends to stockholders were reduced. *Third*, the salaries of officers and clerical staff were cut. I think you have seen something quite different during the last year. You have seen dividends cut first, then the salaries of officers and clerical forces reduced, while the wages of employees generally were maintained—as a later measure, distribution or "staggering" of the time of employment of the wage earners, and last of all a cut in wages. The marked change in the social consciousness of the people is reflected in the medical societies and dental societies, whose members are interested in and discuss economic questions—and are *studying* them. We recognize that in human nature the first thing a man thinks about is himself. When he gets a little bit more developed, he thinks in groups as we do. Then he must finally think in terms of the community. I agree with Dr. Davis that we

must be community minded, and realize that our professions have to meet a very definite public need.

There is a very marked difference in this state between medical service and dental service. Philanthropy has provided an enormous amount of medical service not only for indigents, but also for those of the laboring classes who are supposed to earn enough money to pay their doctor bills. This provision for medical service exceeds the present provision for dental service. It is obvious that under present conditions adequate medical service and adequate dental service cannot be provided for the whole population. We must recognize, also, that the plans that may be adopted here will be organized, as in Europe, primarily to take care of the groups in the lower schedules of income, somewhere around $3000 or $3500. It will be primarily for those who do not pay taxes, but who have votes. When they once make up their minds as to what they want, they will get it.

How are we going to provide a modicum of care? For a number of years I have been interested, as some of you know, in trying to extend the amount of medical service to those who cannot get it—and, I will admit, in my younger days without any particular thought of how that might affect the economics of the profession. In New York City and some other large cities in this state, the amount of free medical-service now given to the laboring class—the income-earning class, not only indigents— is so great that it is in definite competition with large numbers of physicians. It is probable that none here present would be affected by an insurance plan in this state. The patients who come to you are the type who send their children to colleges and universities, and perhaps to private schools. The majority of children go to public schools. I would like to see all the school children in New York City given at least some modicum of dental care—at least cleaning, and temporary filling and extraction. We know that hundreds of thousands of them do not get that much dental care.

We are going to have some form of insurance. It may begin as a voluntary scheme. When we think of health insurance, let us remember that there are many types of insurance. Some of you are fortunate enough to own automobiles and know there are several types of insurance. It is worth while to you to have a form of automobile insurance. We might have a scheme of health insurance that would mean voluntary or compulsory contributions by individuals in consideration of a certain sum payable on demand, to be turned over directly to the individual for the employment of any doctor he might want; or some form of health insurance that would pay the worker for the time lost during illness; or a combination of the two. We might also have a form of voluntary insurance where the county

medical society or dental society would contract with the insurance carrier to do certain forms of work at certain rates. There are many possibilities in insurance schemes. I feel sure we will have to try something to provide further care in both medical and dental branches for the great mass of the people. How it can be done, I do not know. It is a very important sign of the times that medical associations and dental associations are discussing these matters. They will be informed, and will have individuals trained and ready to formulate satisfactory plans when the discussions culminate in the need or opportunity for action. We cannot assume that any scheme of insurance service will be wholly satisfactory to either profession, because no scheme was ever perfect. We would not have the money needed to provide perfect service. We speak in our offices—you do, and I used to—of things that are "necessary" for the patient to have and for the patient to do. Yet, under an insurance scheme and a relatively small amount of money available per capita, a great many things will no longer be *necessary*. If I may use just a broad example: a resident or house physician in one of our hospitals may say that for every patient who comes into the hospital an x-ray must be made of his entire body—and a differential blood count; both are "necessary." They may reveal something that is useful, some information that is valuable. Some of you may say to your patients: "It is really 'necessary' for you to have an x-ray taken of your mouth." But it is unthinkable that we could have every school child of New York given an x-ray examination. In other words, any type of insurance service that may be proposed will have to be sharply limited. If you could provide only cleaning, temporary filling and extraction for all the people of New York City, they would get infinitely more than they receive now. Some of you might then decide how many more dentists that would require. You might well take to heart the story Dr. Phillips has given you about Germany and the use of technicians. Would competent dentists be willing to clean teeth, or would they leave that to young women trained as hygienists? Would they make temporary fillings, or even permanent fillings of some sort, and do some extractions for a very small amount of pay, or would they have that done in a larger clinic, with a dentist in charge of it?

Many doctors tell me that as soon as a doctor is employed on a salary, he is no longer any good. He apparently loses caste. I have never been able to see it. If it is true of the human nature of the physician, it must also be true of the dentist, and of persons who are not in any profession. When a man is on a salary, he comes under supervision. Doctors do not like supervision; neither do dentists. In any scheme of insurance, or any scheme to aid the large mass of humanity to get dental and medical care, there must be some kind of supervision.

Our doctors criticise European systems because they do not know the details and do not recognize the advantages. I have heard many of them give long discussions on the disadvantages of the British panel system, the disadvantages of the Krankenkasse, but I think I hardly ever heard anyone mention any of the advantages. There are advantages, chief among them being the fact that a great number of the public receive better medical care because otherwise they get none, and receive some dental care because otherwise they get none; and more money is expended for health service. If medical and dental service are of any value at all, that means more service; and more service ought to improve the health of the individual, and ought to increase his earning capacity.

Thomas Parran, Jr., M.D. (Albany, New York): I congratulate Dr. Phillips on his splendid exposition of a very complicated subject. It is difficult to convey, in a short paper, a complete picture of health-insurance schemes or other aspects of the health organization. Dr. Phillips certainly grasped fully the fundamentals in his discussion of the health-insurance systems in Europe. We have progressed from an agrarian to an industrial civilization. The income of the great mass of our people has been transferred from agricultural pursuits and trading to salaries and wages in industry. We have approached the necessity for some method of providing in advance for the cost of illness. When a wage earner is ill, wages stop. When a person living on a farm is ill, unless it is a protracted illness, his income is not very much affected. The United States is the only industrial country in the world which has not as yet adopted some form of health insurance. I believe some type of insurance is inevitable in this country. The principle is sound and seems to be accepted by almost every one, but it is equally certain that no existing system in any European country could be transported bodily to the United States and made to work here with our forty-eight different types of state governments. It is inevitable that we will have different systems suited to particular needs. There will be no one national system.

The present system of medical and dental practice in this country is not ideal. This is true also of the solutions that have been attempted by insurance schemes in European countries. I think it is a fair statement, however, that in the countries having health insurance, medical practice and dental practice have been benefited; and that public health has been better served under systems of insurance than under the pre-existing system of individual initiative and private practice. I believe the situation in Great Britain was summed up well in a statement made to me some five or six years ago by a medical officer of health when he said: "The best and worst we can say

about our system of health insurance is that it is just one step in advance of the archaic system of private practice under which we formerly existed." Dr. Phillips referred to the report of the British Medical Association. I wish he had had time to elaborate somewhat upon it, because I have noted that our medical journals have been strangely silent in regard to it. I think it would pay any of you to read a copy of that report of the British medical profession itself—the organization in Great Britain that corresponds to the American Medical Association here—in which, as its major conclusion, it is stated in effect that further improvement of the public health of that country could best be made by building on the foundation of their system of health insurance. That was the conclusion of the organized medical profession of Great Britain. You must remember that in Great Britain they have made only a feeble start toward securing medical care for those in need of it. It is only the wage earner with an income under a certain minimum who is insured. The family of the wage earner is not insured. Only recently they added a specialist phase, including dental service. It is chiefly a home and office service for wage earners by general practitioners; hospital care and specialists' care are not yet included. It is a long step between what they now are receiving and what could be termed complete and adequate medical service. The report of the British Medical Association attempts to define the lines along which they should build for the future improvement of the public health in that country, embraces all methods for the prevention and control of disease, and outlines a unified and ideal national scheme toward which the country should strive. Few people realize that in this state we now have a large measure of "state medicine." We practise state medicine in the care of the insane and in the care of tuberculosis, through the county and state tuberculosis sanatoria. We have made a start in state medicine in the treatment of venereal disease; 40 percent of all cases of syphilis in up-state New York are being treated at public expense. The application of maternity and infant-hygiene measures are state medicine, as are also the treatment of handicapped children at state expense. Similarly immunization measures against smallpox and diphtheria may be called state medicine.

The question that confronts us is whether we should shut our eyes to the question of general medical care. Can we consider that a death from appendicitis, or disability from rheumatism or a focal infection, is less of a public-health problem than death or disability due to typhoid fever, tuberculosis, or syphilis? I think you will agree with me that the public health suffers in either case. On the other hand, we realize that public-health authorities have not been able to encompass the field of prevention that we have already

staked out as our own, and in which we are trying to function, but as yet very incompletely. As we do not render a complete service in the prevention of disease, it seems rather futile to dissipate our energies into the whole field of treatment of diseases while so much remains undone for their prevention. In most of the European systems of insurance the primary emphasis has been laid upon a system of insurance for persons in the lowest economic classes. In this state we need to apply more fully the provisions of present laws, before we consider a system of health insurance. In this and other states there are certain movements that will do much to promote health, although not meeting exactly the same need as health insurance. I refer first to the New York Public Welfare Law enacted two years ago. This law takes out of the realm of charity, and pauperism, the privilege of medical relief. That law says medical care is available and shall be furnished by local public-welfare commissioners to persons ordinarily self-sustaining who temporarily are unable to pay for such services. The full intent of the law has not yet been realized, all over the state, because the law is administered by the same persons who previously administered the old poor-laws. This law represents a remarkable social advance in recognizing the responsibility of taxpayers for providing medical care in the homes and in hospital care for patients who are not able temporarily to pay for those services. The second law, which I think will go far toward meeting the needs of medical care, particularly in rural districts, is the one under which counties may establish county general-hospitals. If a rural county by vote of the people establishes a county general-hospital, state aid may be given subject to the approval of the Commissioner of Health. Every citizen of the county is entitled to admission to that hospital regardless of ability to pay. Rates are so established that if the citizen is able to pay in full, these rates are charged. If he is able to pay nothing, treatment must be given without charge. Three counties have adopted the provisions of this law, and a number of additional applications are before us now. In the immediate future we shall see a great extension in public hospitals, particularly in this state, under the provisions of the County General-Hospital Law. Under the provisions of the Public Welfare Law, and of the County General-Hospital Law, we have the opportunity to provide some medical care for persons unable to pay.

There remains a group that possibly needs to be taken care of by insurance, the group above the economic level of those who would accept public treatment. As to how that need can be met, I confess I have no answer. Like Dr. Davis and Dr. Williams, I believe this problem is a subject for experimentation and study. When a committee after working five years on this subject—the Committee on the Costs of Medical Care, composed of

leading persons in the United States—has no definite proposal to make, certainly it would be foolhardy for one of my own limited knowledge to say he has the answer. We have been raising questions, this evening, rather than answering them.

Shirley W. Wynne, M.D. (New York City): I came here tonight to listen, and not to discuss the paper of the evening. I have profited by listening to Dr. Phillips' paper and the ensuing discussion. We who have been interested in public health have long felt that the majority of the people of our community, in fact of the country, were not receiving adequate medical and dental care. It is encouraging to see an association such as yours devoting an evening meeting to the discussion of a problem that is so vital to the dental profession and to the public. We are in a changing era. We are groping our way. We have gradually moved on from the time when the physician was a wandering medicine man receiving whatever fee or gratuity was handed to him by the grateful patient. We have moved on from that period when the hospital was the poorhouse, intended to provide some sort of care for the sick poor, to that stage where scientific treatment is afforded all people. While we have made progress in the treatment and care that we are giving the public, we have not made progress in reorganizing our methods of dispensing or selling that service.

In an article in one of the leading monthlies recently, a writer spoke of the splendid business men of great capacity and ability who run the finances of the world but who, as trustees of a hospital become "panhandlers" because, instead of using the brains and ingenuity in providing medical and hospital care for the public that they use in their business, they go among their friends asking alms for people who do not want charity. I think we of the dental and medical professions are beginning to change our attitude toward the financial side of our work, and are coming to realize that some method must be found to level the cost of medical and dental care. We now realize that every person in the community is entitled to the best that can be had in the way of medical and surgical care. True, that best may be stripped of all the luxury of private rooms or suites, of double shifts of nurses both day and night. But so far as the fundamentals of that care are concerned, all in the community are entitled to the best that the wealthy can afford. It is our problem, as I see it, to provide the best in dentistry, medicine, and surgery at costs within their reach.

Dr. Davis has said it is difficult to make medicine or dentistry attractive, that people do not want medicine or dentistry as they want a radio or an automobile. That is quite true. But through our health departments,

through our organized medical and dental organizations, we can advertise, not the curative process with its accompanying pain in the dentist's chair or on the operating table, but good health and the methods of preventing illness. That is just as attractive as radios or automobiles. Another stumbling block that I think Dr. Williams pointed out is the fact that most doctors and dentists do not like supervision. We have grown up as individuals. We do not like any person to criticise our methods. After all, in this present day of medicine and of surgery, if one thing is needed more than anything else, it is adequate supervision of the work that is done, particularly in surgery. No system of medicine will bring adequate and competent medical and surgical service to the people of this or any other community until we provide adequate supervision of the work done by the members of our profession. That is a fact that we should face. It will be far better for us to face it ourselves, and bring about that supervision, than to have the laity who are unfamiliar with the problems of medicine, surgery, and dentistry force it on us, as surely they will if we do not take the lead ourselves.

It is heartening to all of us interested in the public health phases of this problem, and no less interested in our profession, to see the various groups, in the last year or two, giving serious thought to formulating a plan that will bring medical, surgical, and dental care to the great mass of our people at costs within their means. I think we are all convinced that some such system is coming. If we have profited by the experiences of brethren abroad, we will take an active part in formulating that program; which therefore will be more satisfactory to us and which, I think, will bring better service to the public.

Dr. Phillips (*in conclusion*): I thank all of the discussers for what they have said. The most important thing in the whole matter is the attitude of the dental and medical professions. Its members are scientists. The scientific attitude toward a problem is the demand that it be investigated. To that end innumerable experiments have been carried out to determine the best methods of procedure in our professional practice. Research is in progress all over the world in regard to the diseases we treat. We are continually finding new methods for the perfection of our practice. But our training and our research are valuable only to the extent that they are applied to the lives of the people. It is our task as professional men to find ways whereby the results of our training and our research can be applied in practice to all. Until we find such a comprehensive method, or until we have investigated and experimented with many methods, our professional responsibility will not have been met.

I should like to urge two or three of the younger men of this Academy to make a thorough study of what has been taking place to provide medical care in this state. Study the workmen's-compensation law. Study the developments that Dr. Parran spoke of. Here you have all the elements of insurance, of state medicine, of things that the professions in the United States are intensely interested in, but are generally opposed to. I do not think you could perform a greater service than to make a thorough study of them, and then interpret them to the health-service professions.

STATUS CALCIFAMES

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"*Status calcifames*" is calcium hunger. It is manifested in many women by a severe headache during and after menstruation. *Predisposing factors* are status calciprivus—calcium starvation due to different causes, and producing a disturbance in mineral metabolism that is fatal to normal dentition, not only in the mother but also in the offspring. The *symptoms* include irritability, hypersensitiveness, mental depression prior to a more or less abnormal menstrual period, followed by an intense headache, lasting sometimes as long as ten days. There is disturbance of the acid-base balance, causing a chronic acidosis.

Diagnosis is based upon the symptoms just mentioned. There is abnormal response of teeth (nerve endings) to a small amount of electric current from the vitalitester; a salivary pH too acid for the patient's age allowance; often active decay. X-ray observation of the portion of the mandible from cuspid to third molar shows marked disappearance of bone speculae. *Prognosis* is good. Headache disappears with elimination of the calcium assimilative "error," which may be due to the following causes: (*a*) Insufficient intake of calcium in the food. (*b*) A hypochlorhydria or achlorhydria, causing diminution of the amount, or non-ionization, of the calcium, and preventing Ca-assimilation in the duodenum. (*c*) Hyperthyroidia, which eliminates excess in the amount of calcium by way of the fecal matter. (*d*) Chronic acidosis, due to chronic infections, vitamine starvation, metabolic disturbances, endocrine defects, or disturbance of digestion. (*e*) Lack of sunshine.

Treatment. As a rule, 20 grains of calcium gluconate, plus 10 drops of Viosterol three times a day, will stop the headache in one day. With continuation of proper treatment and adjustment of diet, head-

ache will not reappear. The syndrome is of the utmost importance to the dental profession, and its recognition and proper therapeutic treatment is necessary in the practice of preventive dentistry.

Bell has shown that the menstrual discharge is rich in calcium, whereas simultaneously the circulating blood contains a diminished amount. *Hoppe-Seyler* claimed that menstrual blood rarely exceeds 37 cc. The age at which menstruation begins varies in different countries, starting earlier in warm climates than in cold ones. This difference is no doubt related to the greater amount of sunlight and activation in the warmer climates. *Mary Putnam Jacobi*, in 1876, advanced the so-called menstrual-wave theory. The metabolic processes in woman present a distinct rhythm, which gains its highest intensity just before menstruation sets in, to start again from the lowest point. *Broderick*, in his "Dental medicine," suggests that the menstrual discharge functions to eliminate a useless calcium surplus (page 89). He also says the calcium ions possess the power of limiting the excitability of the nerve cell, and that the potassium ions increase it. In the course of a conversation, Mrs. Wielage pointed out the possible connection between calcium metabolism and ovarian activities (egg-shells in birds). The hardness and thickness of the shell no doubt depend on proper mineral feeding of poultry. *Price* has called attention to the influence of vitamine D on proper calcium assimilation. *Aub* has established the fact that the storehouse of calcium is in the speculae of long bones and that parathormone, which is the catalyzing agent of the parathyroid gland, loosens the calcium from the bone speculae and makes it available for the blood. The mandible is of the long-bone variety. He also found that in hyperthyroidia, calcium is excreted with the fecal matter in excess of the amount ingested. *Meyer and Gottlieb* point to the increased amount of cholin in the blood, and perspiration, during menstruation. Cholin, belonging to the muscarin group, is a stimulator of the parasympathetic nervous-system. This system stimulates the anabolic group of glands to which the ovaries belong, this influence being antagonistic to thyroid activity. The increased amount of cholin and ovarian activity counteract the adrenal secretion that stimulates the catabolic group of glands to which the thyroid belongs. Hypothyroidia induces melancholia and depression. It would be of interest to compare the amounts of cholin

in blood and perspiration during pregnancy. There seems to be no doubt that calcium metabolism is directly involved in the menstrual phenomena, and that the recognition of "status calcifames" by the dentist or physician is of the uttermost importance to preventive dentistry.

The radiographic diagnosis should include a close study of the portion of the mandible aforementioned. Observation of this region of dimineralization in women should lead to the proper treatment of these patients. The tooth buds start to develop at the sixth week of pregnancy. Healthy dentition in the child, and preservation of tooth structure in the prospective mother, require that prenatal care should be given by the general practitioner or obstetrician from the time of conception. Close coöperation between the family dentist and the family obstetrician insures proper application of preventive dentistry and medicine, with a possible elimination of rachitis.

Oral diagnosis, as practised by the dentist, should include: (*a*). Case history. (*b*). Full-mouth radiographs, including the study of bony tissue. (*c*). Trans-illumination. (*d*). Use of vitalitester, and proper application in relation to hypersensitiveness. (*e*). Microscopic examination for Vincent's infection. (*f*). Salivary pH test to determine the acid-base balance. (*g*). Inquiry as to diet (adjustment of same, if faulty, in coöperation with the patient's physician). (*h*). Clinical examination of oral cavity. (*i*). Laboratory findings and report of physical examination from family physician. The diagnosis of status calcifames, where it exists, is very important for the general dentist and orthodontist, and also for the obstetrician and physician. Adequate therapeutic treatment removes the stubborn headache in the patient. Preventive dentistry should start with proper treatment of the unmarried female patients in which status calcifames may be detected.

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REFERENCES TO LITERATURE

AUB, J. C. Calcium and phosphorus metabolism, *Harvey Lectures*, 1928–29, p. 159. A study of the bone trabeculae as a readily available reserve supply of calcium, *Journal of Experimental Medicine*, 1929, xlix, p. 145. The effect of the parathyroid hormones, *Journal of Clinical Investigation*, 1929, vii, p. 178. The effects of the thyroid hormone and thyroid disease, *Ibid.*, p. 113.

BELL, B. The relation of the internal secretion to the female characteristics. *Proceedings of the Royal Society of Medicine, Gynecology, and Obstetrics*, 1914, vii, pp. 47 and 76.

BRODERICK, F. W. Dental medicine, pp. 65 and 89, 1928; C. V. Mosby Co., St. Louis, Mo.

CROSSEN, H. S. Diseases of woman, p. 828, 1922; C. V. Mosby Co., St. Louis, Mo.

MEYER, H. H., AND GOTTLIEB, R. Experimentelle Pharmakologie. Siebente Auflage, p. 302, 1925; Urban and Schwarzenberg, Berlin, Germany.

PRICE, WESTON A. Calcium metabolism studies, *Journal of the American Dental Association*, 1929, xvi, p. 265.

WILLIAMS, J. W. Obstetrics, pp. 84, 90, and 190, 1921; D. Appleton and Co., New York.

PHYSICO-CHEMICAL STUDIES ON THE STRUCTURE OF DENTAL ENAMEL[1]

IV. The Cataphoretic Determination of the Effects of pH and Electrolytes on the Electric Charge Resident on Enamel Particles

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Introduction. When a difference of potential is established between two electrodes that are immersed in a liquid containing finely divided particles, these particles move toward one of the electrodes. This electric phenomenon has been termed cataphoresis (the movement of a solid phase through a liquid phase in response to a potential difference). If the particles move toward the negative electrode, they are positively charged; if they move toward the positive electrode, they possess a negative charge. By this method the nature of the charge on a colloidal particle may be readily determined. The sign of the charge on a solid phase suspended in a liquid menstruum is dependent upon a number of factors, of which the most important are the chemical nature of the particle and of the liquid in which the particle is suspended. Electrolytes exercise a marked effect upon the nature of the charge on the particle (1).

In a study of the physico-chemical properties of enamel (2, 3, 4), it became of some interest, in order to understand the electrical effects obtained on enamel membrane, to determine the nature of the electric

[1] Previous publications in this series: (I) Physico-chemical studies on the structure of dental enamel; *Journal of Dental Research*, 1929, ix, p. 667. (II) Physico-chemical studies on the structure of dental enamel: A quantitative method for determining relative differences in the permeability of the teeth; *Ibid.*, 1930, x, p. 477. (III) Physico-chemical studies on the structure of dental enamel: A method for determining the rate at which a salt may penetrate the enamel; *Ibid.*, 1930, x, p. 727.

[2] Research Fellow supported by grants from the American Dental Association and the Dental Staff of Johns Hopkins Hospital.

charge on enamel; also the effects of acidity, alkalinity, and electrolytes on that charge. When finely divided enamel particles are suspended in a liquid menstruum in an electrical field, and cataphoretic determinations made, the migration of the particles should give some information concerning the electrical charge thereon.

Experimental. In the preparation of finely divided enamel particles, cuspid teeth of dogs were obtained by sawing and chiseling the teeth out of the bony alveolar socket; they were then scrubbed and cleansed with distilled water to remove food and organic debris from the enamel surface, and dried in a clean container, the entrance of dust particles

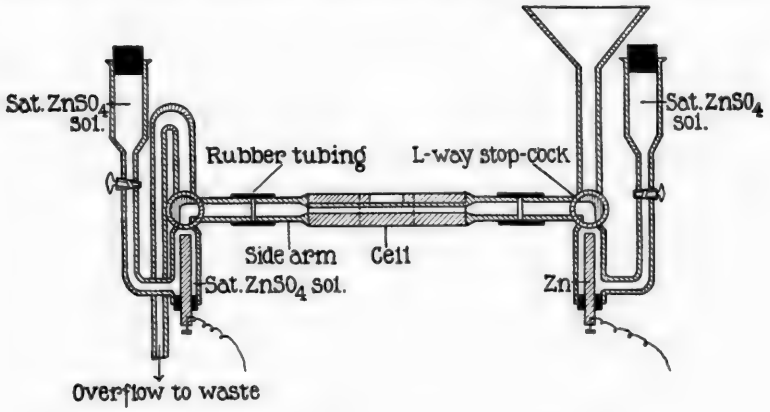

FIG. 1. APPARATUS USED FOR THE CATAPHORETIC DETERMINATIONS

having been prevented. After drying, the teeth were held firmly by the roots, and finely divided particles of enamel collected in a clean dish by grinding the enamel surface with a clean, new, cross-cut dental-bur. The powdered enamel thus collected was divided into three major portions: for determinations in solutions of KCl, and $CaCl_2$, and for studies of the effects of acidity and alkalinity, respectively. The portion reserved for determinations in KCl solution was subdivided into three parts, and these suspended in 0.001 *M* KCl, 0.01 *M* KCl, and 0.1 *M* KCl, respectively.[3] The portion reserved for

[3] The various molar strengths were used to determine the effects of the different concentrations on the cataphoretic charge.

determinations in $CaCl_2$ solution were similarly divided and suspended in 0.001 *M* $CaCl_2$, 0.01 *M* $CaCl_2$, and 0.1 *M* $CaCl_2$, respectively.[3] The remaining quantity of enamel particles was divided into six equal parts, and suspended in $\frac{M}{250}$ KCl, each mixture having been adjusted

TABLE 1

The effect of salts on the cataphoretic speed of enamel particles

SALT	MOLAR SALT CONCENTRATION	LEVEL OF CHAMBER	CHARGE ON PARTICLE	READING[1]	NUMBER OF DETERMINATIONS
KCl	0.001	1	+	16.5	3
		2	−	10.5	6
		3	−	9.7	5
	0.01	1	+	30.0	5
		2	−	10.0	5
		3	−	8.5	5
	0.1	1	+	Very slow	Few
		2	−	23.0	5
		3	−	19.2	5
$CaCl_2$	0.001	1	+	17.0	2
		2	−	16.4	5
		3	−	10.5	5
	0.01	1	+	60.0	3
		2	−	31.6	5
		3	−	22.8	5
	0.1	1	+	Very slow	
		2		No movement	
		3	−	50.0	6

[1] Reading: seconds required to cross 2 mm.

to a different though definite pH by addition of hydrochloric acid. Each of the twelve mixtures was thoroughly shaken and allowed to stand. The larger particles of enamel settled to the bottom. The finely divided particles remained in suspension.

The electric charge on the finely divided enamel particles was then determined by a cataphoretic method, with an adaptation of the cell

described by Kunitz (5), consisting of a piece of pyrex tubing, the middle section having been flattened to form a small, oblong, box-like chamber that fits under the objective of an ultra-microscope (6) through which the particles appeared like bright stars in a dark field. The two ends of the pyrex tubing were connected to zinc-zinc sulphate electrodes, to establish an electrical field across the cell. Provision

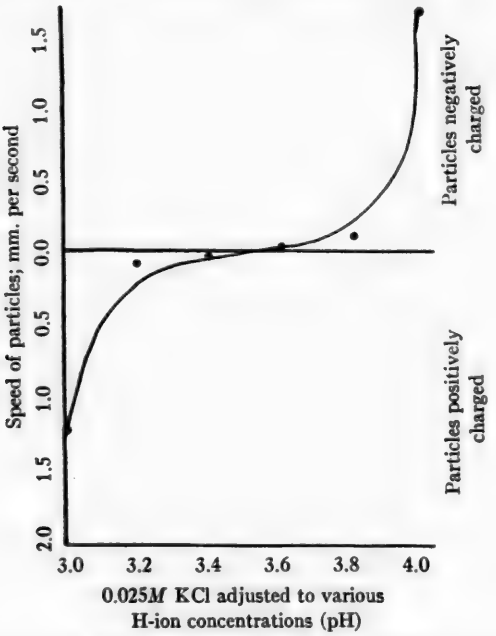

FIG. 2. GRAPH SHOWING RESULTS OF CATAPHORETIC DETERMINATIONS FOR ENAMEL PARTICLES IN 0.025*M* KCl SOLUTION ADJUSTED TO VARIOUS HYDROGEN-ION CONCENTRATIONS

was made for the placement in the cell of the particles suspended in their respective solutions. When the current was established through the cataphoresis chamber, the speed of migration of the enamel particles across the field was determined with a stop watch and an ocular micrometer. A diagram of the chamber is shown in *fig. 1.*

Readings of the cataphoretic velocity of the enamel particles were made at three levels in the upper half of the cataphoresis chamber.

The true sign of the charge is obtained in the second and third levels, the readings in the first level adjacent to the wall of the chamber being complicated by the effects of electro-endosmotic streaming. The details of the theoretical treatment of this complication will not be dealt with here. The reader is referred to Freundlich (7) and Abramson (8).

Results. The enamel particles in KCl solutions, within the electrical field, moved toward the positive electrode. In $CaCl_2$ solutions, they moved less readily toward the positive electrode. In KCl solutions having hydrogen-ion concentrations on the acid side of pH 3.6, the particles moved toward the negative electrode. In solutions of KCl having hydrogen-ion concentrations less than that for pH 3.6, the particles migrated toward the positive electrode. These relationships are shown in *Table 1* and *fig. 2.*

Summary. Suspended in KCl solutions (0.1, 0.01, 0.001 *M*), enamel particles are negatively charged; in $CaCl_2$ solutions (0.1, 0.01, 0.001 *M*), they tend to become positively charged.

Suspended in $\frac{M}{250}$ KCl solutions more acid than pH 3.6, enamel particles are positively charged; in such solutions more alkaline than pH 3.6, the particles are negatively charged.

REFERENCES TO LITERATURE

(1) Loeb, J. *J. General Physiology, 6,* 307 (1924).
(2) Klein, H., and Amberson, W. R. *J. Dental Res., 9,* 667 (1929).
(3) Klein, H. *J. Dental Res., 10,* 447 (1930).
(4) Klein, H. *J. Dental Res., 10,* 727 (1930).
(5) Kunitz, M. *J. General Physiology, 6,* 413 (1924).
(6) Getman, F. H., and Daniels, F. Outlines of theoretical chemistry, p. 210; John Wiley and Sons, New York (1931).
(7) Freundlich, H. Colloid and capillary chemistry; E. P. Dutton Co., New York (1926).
(8) Abramson, H. A. Colloid symposium monograph, viii, p. 289 (1930).

PHYSICO-CHEMICAL STUDIES ON THE STRUCTURE OF DENTAL ENAMEL

V. The Effects of Acidity and Alkalinity upon the Nature of the Electric Charge Resident on Particles of Tri-calcium Phosphate

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A previous communication[2] has shown that enamel particles in KCl solutions more acid than pH 3.6 possess a positive electric charge; in KCl solutions less acid than pH 3.6, a negative charge. This reversal of charge indicates that enamel possesses amphoteric properties, and, occurring close to the range of pH at which certain proteins reverse their charge, suggested that the observed effect might be due to a protein constituent. Accordingly, it became of some interest to determine whether tri-calcium phosphate shows properties similar to those displayed by enamel.

Pure tri-calcium phosphate was thoroughly ground in a mortar to a very fine powder, which was then washed repeatedly with distilled water. Into sodium acetate buffers[3] covering the following pH range, 3.64, 4.06, 4.44, 4.69, 4.85, were put approximately 5 grams of the finely divided and washed tri-calcium phosphate, and cataphoretic determinations made, using the technique described in the preceding paper.[2] In the buffers having a pH-range between 3.64 and 4.06 the particles were positively charged; between 4.30 and 4.40, uncertainly negative; between 4.69 and 4.85, definitely negative (*Table 1*).

Summary. Tri-calcium phosphate particles in acetate buffers act as an amphoteric substance, possessing a negative charge at pH 4.69, and a positive charge at pH 3.64.

[1] Research Fellow supported by grants from the American Dental Association and the Dental Staff of Johns Hopkins Hospital.

[2] Klein: *Journal of Dental Research*, 1932, xii, p. 79; preceding paper.

[3] Clark: Determination of hydrogen ions (1928); Williams and Wilkins Co., Baltimore.

TABLE 1

Data of cataphoretic tests of tri-calcium phosphate: at least three readings at each level

pH	LEVEL	CHARGE	READING*	pH	LEVEL	CHARGE	READING*
3.64	1	+	31	4.44	1	+	68
	1	+	32		1	+	80
	1	+	33		1	+	94
	2	+	49		2	−	80
	2	+	50		2	−	56
	2	+	60		2	−	52
	3	+	64		2	−	46
	3	+	89		3	−	27
	3	+	98		3	−	32
					3	−	30
3.64	1	+	59	4.69	1	+	60
	1	+	42		1	+	60
	1	+	33		1	−	92
	2	+	54		1	−	96
	2	+	48		2	−	28
	2	+	44		2	−	20
	3	+	53		2	−	25
	3	+	50		3	−	20
	3	+	49		3	−	23
					3	−	24
4.06	1	+	32	4.85	1	−	53
	1	+	45		1	−	60
	1	+	49		1	−	72
	2	+	35		2	−	26
	2	+	36		2	−	28
	2	+	40		2	−	26
	3	−	94		3	−	15
	3	−	140		3	−	13
	3	−	56		3	−	14
	3	−	50				
	3	−	54				
4.30	1	+	36				
	1	+	32				
	1	+	33				
	2	+	68				
	2	+	62				
	2	+	76				
	3	−	108				
	3	−	88				
	3	−	70				

* Reading: seconds required to cross 2 mm.

PHYSICO-CHEMICAL STUDIES ON THE STRUCTURE OF DENTAL ENAMEL

VI. The Electro-endosmotic Determination of the Electric Charge Resident on the Enamel Pore-wall; the Influence of Acidity and Alkalinity of the Bathing Salt-solutions[1]

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Introduction. The movement of a liquid through a porous membrane, due to passage of an electric current between two electrodes on opposite sides of the membrane, is known as electro-endosmosis. This phenomenon was first observed by Reuss in 1808, but no concept for the phenomenon was available until Perrin[3] proposed the theory of the "electric double layer." He suggested that two layers of electricity—one positive, one negative—exist at a very short distance from each other at the boundary of fluids with solids, one layer forming a coating on the surface of the solid and adhering to it, the other being immediately adjacent in the fluid medium. When the solid phase consists of a porous membrane, the surface of the pores possesses an electrical charge, while the fluid layer immediately adjacent (filling the pore) carries a charge opposite that on the pore wall. When an electrical current crosses the membrane through the pores, the water in the pores, being charged, moves toward the electrode having a charge opposite that on the water. By noting the direction in which the water moves, the charge thereon may be readily determined; for, if it moves toward the negative electrode, the water in the pore is positively charged. Since, as previously noted, the solid phase always has a

[1] The effects of $CaCl_2$ and KCl solutions were described in a previous communication—Klein and Amberson: *Journal of Dental Research*, 1929, ix, p. 667.

[2] Research Fellow supported by grants from the American Dental Association and the Dental Staff of Johns Hopkins Hospital.

[3] Perrin: *J. Chim. Phys.*, 1904, ii, p. 601.

charge opposite that on the fluid immediately adjacent (electric double layer), a determination of the direction of water flow through the membrane identifies the sign of the charge on the water, and also the sign of the charge on the pore wall. Thus, if the water moves toward the negative electrode, the water in the pore is positively charged, indicating also that the pore wall is negatively charged. Electro-endosmotic determinations, then, present a means by which the nature of the charge on the pore wall may be ascertained, just as cataphoretic determinations identify the charge on a particle.

The nature of the charge on the pore wall of a membrane constitutes an important factor in the production of membrane potentials across that membrane. A determination of the influence of acidity and alkalinity on the charge on the enamel pore-wall is described below.

Experimental. Electro-endosmotic determinations were carried out with the apparatus and set-up described in an earlier publication.[4] The apparatus was filled with a sodium acetate buffer solution, pH 4.97, having a sodium acetate concentration of 0.035 *M*. The buffer solution also filled the inside of the enamel cup. The stopcocks were then turned so that the inner surface of the enamel was in electrical contact with the zinc-zinc sulphate electrode through the acetate buffer, which filled the connecting tubes. The system was then entirely closed, excepting the capillary tube, which remained open to the air. Movements of water under the influence of the applied current were read upon the graduated capillary. The tip of the tooth was immersed in another portion of the acetate buffer, at the same pH, and electrical connection completed through a platinum electrode. The current was then applied. With the inner surface of the enamel cup in electrical contact with the negative pole, the water in the capillary tube rose, indicating that the water was passing toward the negative pole (from outside the tooth to the inside); also showing that the water in the enamel pores was electro-positive, and that at pH 4.97 the enamel pore-wall was negatively charged (opposite that of the adjacent water).

The electrodes were then reversed, so that the inside of the tooth was in electrical connection with the positive electrode. If the pore wall were negatively charged, at pH 4.97, the water, then positively charged,

[4] Klein and Amberson: *Journal of Dental Research*, 1929, ix, p. 667.

TABLE 1

Electro-endosmosis through enamel: effect of pH of the bathing solutions; pH 4.97 until changed to pH 4.00, as noted[1]

M. A.	DIRECTION OF CURRENT	TIME	TEMPERATURE	READING[2]
0	0	10.00 a.m.	24.9°C.	0.368
0	0	10.40	24.8	0.360
0	0	11.06	25.3	0.365
4	Inside −[3]	11.06	25.3	0.365
4	" −	11.26	25.2	0.385
4	" +	11.26	25.2	0.385
4	" +	11.46	25.6	0.387
4	" −	11.46	25.6	0.387
4	" −	12.46 p.m.	25.5	0.441
4	" +	12.46	25.5	0.441
4	" +	2.30	25.8	0.431
0	No current[4]	2.30	25.8	0.431
0	" " [4]	4.30	24.9	0.429
Not noted	Inside −	4.30	24.9	0.429
" "	" −	5.30	24.9	0.461
" "	" +	5.30	24.9	0.461
" "	" +	6.30	25.1	0.455
" "	" −	7.30	22.5	0.455
" "	" −	8.30	24.5	0.477
" "	" +	9.30	24.1	0.443
0	No current	9.30	24.1	0.443
0	" "	10.30	24.1	0.435
4	Inside −	11.30 p.m.	24.2	0.467
Change here to pH 4.00 next day; tooth overnight in pH 4.00				
1	Inside +[3]	11.45 a.m.	25.2	0.887
1	" +	12.50 p.m.	25.7	0.890
Not noted	Current too low to indicate M. A.; added dry cells			
2	Inside −	5.20	26.1	0.893
3	" −	8.10	26.7	0.882
3	" +	9.15	26.7	0.899
3	" −	10.15	26.5	0.889
	" +	11.15 p.m.	26.3	0.901

[1] The pH of the solution at the end of the run was 4.03.

[2] Reading: height of the water in cc. in the graduated capillary tube. See footnote 3.

[3] At pH 4.97 the volume of water in the tube rose when the inside charge was −; at pH 4.00, it rose when the inside charge was +. This indicates that the membrane reversed its charge from negative at pH 4.97 to positive at pH 4.00.

[4] To check against leaks.

should move toward the negative pole, which is outside the tooth; that is to say, would move from inside the tooth to the outside, and a drop in the capillary reading, owing to the transfer of water, would occur. Such is the case experimentally (*Table 1*). In each case, inside positive or inside negative, the water within the enamel structure appears to be positively charged, for water is transported toward the negative electrode *from* the inside (fall in the capillary) when the inner solution is electro-positive, and *toward* the inside (rise in the capillary) when the inner solution is electro-negative. On the theory of the electric double-layer, the enamel pore-wall at pH 4.97 has a negative charge, since the water within the pores is positively charged.

The sodium acetate buffer, pH 4.97, was replaced by the same kind having a 4.00 pH, and the tooth kept in the latter for 24 hours, when a second series of readings were made. The direction of water transport had been reversed. When the inside solution was made electro-positive, water moved toward the inner solution (rose in the capillary); when negative, water moved from the inner solution (fell in the capillary). This indicates that the water within the enamel pore-walls was negatively charged; the pore wall, positively charged. At 4.00 pH, the charge on the enamel pore-wall was the reverse of that at pH 4.97—positive in the former, negative in the latter.

Summary. By means of electro-endosmotic determinations, using sodium acetate buffers, it was found that the enamel pore-wall has a positive charge at pH 4.0, and a negative one at pH 4.97.

PHYSICO-CHEMICAL STUDIES ON THE STRUCTURE OF DENTAL ENAMEL

VII. The Mechanism of Production of Membrane Potentials (Electrical Differences of Potentials) in the Enamel of Dogs

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Introduction. When two different concentrations of a salt, in separated containers, are connected by a salt bridge with suitable instruments, an electrical current, known as a *diffusion potential*,[2] is set up. When two different concentrations of the salt are separated by a membrane semipermeable for one ion, an electrical current, known as a *membrane potential*,[3] arises. If the membrane separating two different concentrations of a salt solution contains very large pores, the diffusion potential is very slight, and arises only from differences in mobility of the different ions. This condition holds for any membrane having pores, the membrane playing no rôle in the production of electrical current, diffusion from the concentrated solution into the dilute being unhampered by a membrane having large pores. If the salt is 0.1 *M* KCl separated from 0.02 *M* KCl, a membrane with large pores acts as a very slight barrier, the ensuing potential difference being due only to the difference in ionic mobilities of the K ion and the Cl ion. If, however, a membrane containing smaller pores is placed between the two different concentrations of KCl, the ensuing potential difference increases in magnitude as the pore-size diminishes. A very permeable membrane (large pores) produces only slight potential-differences; one that is not readily permeable (small pores) develops

[1] Research Fellow supported by grants from the American Dental Association and from the Dental Staff of Johns Hopkins Hospital.

[2] Freundlich: Colloid and capillary chemistry, 1926; E. P. Dutton & Co., New York.

[3] Michaelis and Perlzweig: *Journal of General Physiology*, 1927, x, p. 575.

high potential-differences, the properties of the membrane playing a rôle in their production. Enamel is such a small-pore membrane.

Mechanism of production of a membrane potential across enamel. When enamel is placed between two concentrations of a salt solution, a demonstrable EMF arises, which is greater than one would expect if only diffusion potentials were present.[4,5] This potential would not arise if the enamel were not acting as an ionic sieve, for then ensuing potentials would be of the magnitude only of diffusion potentials. If more detailed observations are made of the conditions under which membrane potentials arise across enamel, it is always found that where 0.1 *M* KCl is inside the enamel cup, and 0.01 *M* KCl outside, the outside (more dilute solution) is electro-positive; the inner, electro-negative. Hence there must be relatively more positive ions in the solution outside the cup than inside. It is well known that a salt (0.1 *M* KCl inside) will tend to diffuse toward a more dilute solution (0.01 *M* KCl outside). The only way in which the 0.01 *M* KCl solution (outside) can contain a greater number of positive ions than the 0.1 *M* KCl solution (inside) is by action of the membrane—by permitting more positive ions than negative ones to go through. In that event, there is a difference in the amounts of positive ions on the two sides of the enamel cup, which appears as a *difference of potential*. If appropriate electrical apparatus is arranged,[5] a current of ions (electrical current) flows from the outer to the inner solution. The measure of this current is the *membrane potential*. The discussion that follows is an attempt to present a working hypothesis (on the basis of experimental evidence) to explain the mechanism of production of such membrane potentials in enamel.

Let us take one pore of the enamel membrane and consider its behavior. The membrane is bathed on its inner surface by 0.1 *M* KCl; on the outer, by 0.01 *M* KCl. The KCl on the inner surface would ordinarily be expected to diffuse toward the more dilute KCl on the outer. This can be accomplished only by traversing the pores of the enamel. If this diffusion occurs without obstruction by the membrane, then very slight EMFs, or none, arise. The fact that high EMFs do arise[5] means that enamel obstructs the passage of ions.

[4] Klein and Amberson: *Journal of Dental Research*, 1929, ix, p. 667.
[5] Klein: *Ibid.*, 1930, x, p. 447.

The outer solution (when enamel is in KCl) is always electro-positive,[5] indicating that a greater number of positive ions penetrate the enamel than negative ions. When bathed by KCl, this means specifically that enamel permits more K ions than Cl ions to go through. A previous communication[6] has shown that enamel particles in KCl have a negative charge. Since enamel pore-wall (solid phase) is essentially a conglomeration of such particles closely arranged, the pore wall should also be negatively charged. The fact that enamel pore-wall is negatively charged in KCl solution has been experimentally demonstrated.[4]

To recapitulate, it has been demonstrated experimentally that enamel particles in KCl possess a negative charge; that enamel pore-wall (a conglomeration of enamel particles) possesses a negative charge; and that when enamel is bathed on its inner surface by a KCl solution, and on its outer surface by a more dilute KCl solution, the outer is always electro-positive, because of the presence of a relatively greater number of positive ions. It is apparent, then, that the negative charge on the pore-wall of enamel in KCl prohibits or delays the penetration of ions of the same sign of charge (Cl), and facilitates the penetration (transport to the more dilute solution) of ions bearing the charge (K) of a sign opposite that on the pore wall. The enamel membrane in KCl solution acts, then, as an ionic sieve, permitting the penetration of cations and delaying the penetration of anions (because of negatively charged pore-walls), resulting in more positivity of the less concentrated KCl solution outside the enamel cup. This in turn results in a difference of potential, which is measured as the membrane potential.

If this concept of the production of membrane potentials (charged pore-walls delay penetration by ions of the same sign of charge, and facilitate ions of opposite sign, causing a difference in potential) is correct, then if it were possible to make the pore-wall positive instead of negative (pore wall is negative in KCl), the positive pore-wall should delay penetration by positive ions and facilitate penetration by negative ions. If this is possible, then the more dilute solution should be negative because, if the positive membrane permits negative ions to go through more readily than positive ions, the solution outside the enamel cup would contain more negative ions than the inside solution,

[6] Klein: *Journal of Dental Research*, 1932, xii, p. 79; February.

resulting in a higher potential of negativity in the outer solution. That a positive charge may be produced on enamel particles has been reported in a previous communication.[6] That enamel pore-walls may become positively charged has also been experimentally demonstrated.[4]

If now we place 0.1 *M* $CaCl_2$ inside the enamel cup, and 0.01 *M* $CaCl_2$ outside the cup, the inside solution will tend to diffuse to the more dilute outer solution. The pore wall is positively charged as indicated earlier in this paper. Both Ca ions and Cl ions tend to traverse the enamel pore-wall toward the outer solution, which ($CaCl_2$) is always negative (always positive for KCl). This means that the membrane possessing a positive charge is now delaying penetration by the Ca ion, which bears the same sign of charge as that on the pore wall, and facilitates the penetration of the negative ion, Cl. This results in a greater negativity of the outside solution, and in turn results in a membrane potential.

Conclusions. (1) Enamel is able to produce membrane potentials because its structure is such as to make it an ionic sieve.

(2) The nature of the charge on enamel pore-wall plays a significant rôle in determining which ion of a bathing salt-solution will penetrate.

(3) Enamel *facilitates* the penetration of ions bearing the sign opposite that on the enamel pore-wall, but *delays* the penetration of ions bearing the same sign.

(4) The nature of the electrolyte bathing enamel determines the sign of the charge on the pore wall. In KCl, enamel is negatively charged; in $CaCl_2$, positively.

(5) The action of enamel as an ionic sieve, because of charged pore-walls, results in producing a potential difference that is measurable as a membrane potential.

PHYSICO-CHEMICAL STUDIES ON THE STRUCTURE OF DENTAL ENAMEL

VIII. The Determination of the Isoelectric Point of Enamel by Means of Membrane-Potential Measurements[1]

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Introduction. Experiments dealing with effects of acidity and alkalinity on the nature of the cataphoretic charge on enamel particles, and on the enamel pore-wall,[3] have indicated that the isoelectric point of enamel lies between pH 3.6 and 4.9. Previous research[4] had demonstrated that a reversal of sign of the charge on the enamel pore-wall is accompanied by a reversal of direction of the membrane potential, the pore walls being negatively charged in KCl solutions, positively in $CaCl_2$ solutions. Reversal of sign of the charge on a substance, by changing the hydrogen-ion concentration of the bathing solutions, usually indicates that this substance contains or is made up of amphoteric material which dissociates in *acid* solutions in such a way that the dominant charge on the substance is that of a cation (positive); in *alkaline* solutions, that of an anion (negative). If enamel has amphoteric properties, the enamel pore-wall would be positively charged in solutions on the acid side of the isoelectric point, negatively on the alkaline side. That enamel possesses such properties has been experimentally demonstrated.[5]

On the basis of the previously described mechanism for the pro-

[1] Presented at a session of the ninth general meeting of the International Association for Dental Research, Memphis, Tenn., March 21–22, 1931: *Journal of Dental Research*, 1931, xi, p. 477.

[2] Research Fellow supported by grants from the American Dental Association and from the Dental Staff of Johns Hopkins Hospital.

[3] Klein: *Journal of Dental Research*, 1932, xii, pp. 79 and 87; February.

[4] Klein and Amberson: *Ibid.*, 1929, ix, p. 667.

[5] Klein: *Ibid.*, 1932, xii, p. 87; February.

duction of membrane potentials in enamel,[6] reversal of sign of the charge on the pore wall should be accompanied by a reversal in direction of the membrane potential. In order to test this point, and to determine more exactly the isoelectric point of enamel (that pH at which the membrane charge is reversed), the following experiments were conducted.

Experimental. Cuspid teeth from dogs were prepared in a manner identical with that described in an earlier paper.[4] Instead of KCl solutions, sodium-acetate buffers varying in pH from 4.15 to 4.69 were used. They were made in the proportions outlined by Clark.[7] The concentration gradient (molar concentration of salt inside the membrane over molar concentration of salt outside) was constant in all experimental runs, using as the concentrated salt solution the molarity of the sodium-acetate buffer at pH 4.0. The remaining buffers (less acid than 4.0) were diluted so that the salt concentration was the same in all—0.036 molar—the only difference being a graded difference in hydrogen-ion concentration. These solutions are designated as the "concentrated" salt-solutions. The dilute salt-solutions for bathing the outside of the enamel cups were prepared by a fifty-fold dilution of portions of the concentrated buffer-solution. This resulted in a series of buffers having the same graded hydrogen-ion concentrations[8] as the first series, but containing one-fiftieth of their salt concentration. In all cases the pH values of the solutions (concentrated and diluted) were determined by the quinhydrone-electrode method. The technique for determining the membrane potentials across the enamel was the same as that described in our earlier communication, except that the sodium-acetate buffer, 0.036 *M* (concentrated solution), replaced 0.1 *M* KCl inside the enamel cup, and sodium-acetate buffer, 0.00072 *M* (dilute solution), replaced 0.01 *M* KCl outside. The determinations on membrane potential were made in the following manner:

Four enamel cups were set up in the previously-described apparatus.

[6] Klein: *Journal of Dental Research*, 1932, xii, p. 91; February.

[7] Clark: The determination of hydrogen ions, 1928; Williams and Wilkins Co., Baltimore, Md.

[8] Such dilution causes a slight shift in the pH toward the alkaline side; but even when the original standard solutions are diluted one-hundred fold, the resulting change is not more than 0.2 of a pH unit.

Sodium-acetate buffer, 0.036 *M* having a pH of 4.610, filled the enamel cups. The tips of the teeth were then placed in the dilute sodium-acetate buffer, 0.00072 *M* having a pH of 4.615. The concentration gradients across the enamel—0.036 *M* inside over 0.00072 *M* outside the cups—produced an electric current (membrane potential) that was measured with a capillary electrometer and a potentiometer in the four cups in succession. These readings were: tooth #1, 24 millivolts; #2, 27 millivolts; #3, 20 millivolts; #4, 17 millivolts, the outside solution having been electro-positive, indicating that the positive ions were passing more readily than the negative from the inside solution (more concentrated) to the one outside. This indicates[5] that the membrane was negatively charged. It has already been pointed out that at pH 4.61 the enamel pore-wall is negatively charged, as determined by studies on electro-endosmosis.[5]

The four enamel cups were removed from the apparatus and placed in 0.036 *M* sodium-acetate buffer having a hydrogen-ion concentration of pH 4.35. The cup remained in this solution for 24 hours, and then was again placed in the apparatus—0.036 *M* sodium-acetate buffer, pH 4.35, inside the enamel cups; 0.00072 *M* sodium-acetate buffer, pH 4.36, outside. Measurements were then made of the membrane potentials. These read: tooth #1, 3.5 millivolts; #2, 0.3 millivolt; #3, 0.2 millivolt; #4, 1.0 millivolt. These readings indicate that the enamel membrane at pH 4.36 possessed almost no charge, the transfer of the cations and anions from the more concentrated (inside) solution to the more dilute (outside) having been disturbed very little by the membrane because it possessed almost no charge. The membrane did not impede the progress of the ions through the interstices of its structure, and so no separation of the ions was produced and very little potential arose at pH 4.36.

The enamel cups were again removed from the apparatus, and placed in 0.036 *M* sodium-acetate buffer at pH 4.15, remaining in this solution for 24 hours. The cups were then returned to the apparatus—0.036 *M* sodium-acetate buffer pH 4.15 inside, 0.00072 *M* sodium-acetate buffer pH 4.25 outside. Readings on membrane potential were then made. The outside dilute solution was negatively charged; at pH 4.15 the sign of its charge was opposite that at pH 4.61, at which pH it was positively charged. This indicates that the enamel

membrane at pH 4.15 permitted anions to pass more readily than cations from the concentrated solution inside to the dilute one outside.

It has already been shown that at pH 4.61 the enamel pore-wall is positively charged.[5] Therefore, the positively charged pore-wall limits penetration by cations, and facilitates penetration by anions, thus producing an electro-negativity of the outside dilute solution. At pH values more acid than 4.35–4.37, the direction of the membrane potentials indicated that the enamel was positively charged; at pH values more alkaline than 4.35–4.37, negatively charged.

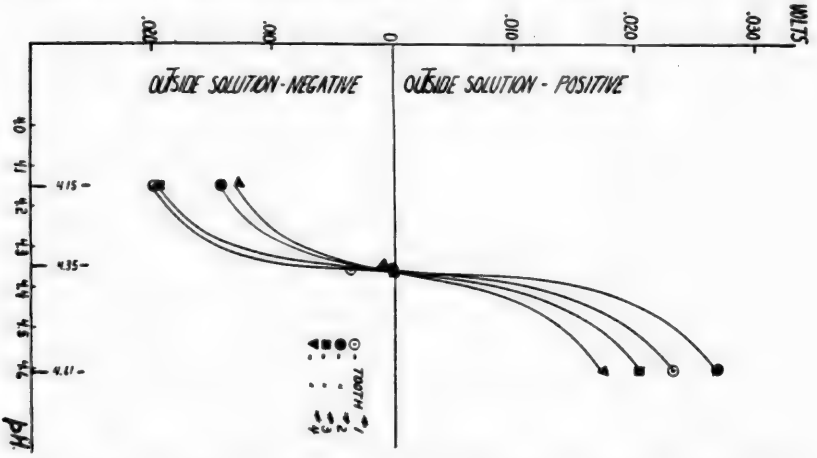

FIG. 1. GRAPH SHOWING THE LOCATION OF THE ISOELECTRIC POINT FOR ENAMEL OF CUSPID TEETH FROM DOGS

The pH at which no membrane potential or very little arises—because the pore wall possesses no charge or very little, so that penetration by positive and negative ions is unimpeded by electro-static forces on the pore wall (isoelectric point)—for enamel of cuspid teeth from dogs, lies between pH 4.33 and 4.37, as is shown in *fig. 1*.

Summary. The isoelectric point of enamel lies at 4.35 ± 0.02, when the determinations are made with sodium-acetate buffers.

THE ORGANIC STRUCTURE OF DENTAL ENAMEL AS A PASSIVE DEFENSE AGAINST CARIES

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I. INTRODUCTION

Although the existence of an organic structure in the enamel of the tooth has been placed beyond question, there is still doubt as to what rôle this plays when the tooth is attacked by caries. On one side we find the proponents of a theory of vital resistance in such men as the Bödeckers, von Beust and Howe, and on the other the followers of Tomes, Hopewell-Smith and Williams who believe that the defense of the enamel is principally one of passive resistance of the inorganic substances. This paper attempts to show that there is another factor which as yet seems to have been ignored; that is, the existence of a passive resistance on the part of the organic element of the enamel. In order to justify this concept, it will be necessary to review the opinions of some previous investigators.

It is generally agreed (4a, 30b) that the organic matter of the enamel exists as a sheath enclosing the enamel rod along its whole length. These sheaths are considered continuous to the surface of the tooth where they join with the cornified enamel cuticle (4a, 30b). This connection has not been shown to exist in every case, but Fish (9) believes the cuticle and the organic matrix to be structurally identical

[1] Rockefeller Fellow in Dentistry.

and in human teeth fully keratinized. The high resistance of the enamel cuticle to the onset of caries mentioned by Malleson (18), Mummery (21), and Leigh (17) would, therefore, suggest a similar property in the rod sheaths. Orban (23) has shown such a cornification to have occurred at the external portion of the enamel lamellae. Another view is expressed by Cape and Kitchin (6) who, as the result of examination of enamel with polarized light and x-ray, conclude that the enamel-rod sheaths differ from the keratin of the cuticle, and the finger nail. Biochemical investigations of the nature of the enamel-rod sheaths support the idea of its keratinous nature (10, 24, 25). In his most recent work, Rosebury (24) suggests that it is more closely allied to the keratinous material of nerve sheaths than to the epidermal keratins. These findings negative effectively the suggestion of C. F. and H. W. C. Bödecker (5) concerning an albumin in the rod substance, and Williams' implication (4a) of a chitinous rod-sheath. Staining reactions of section preparations reported by Chase (8) and Karshan (14) are confirmatory of this keratinous nature. The writer's own observations with a variety of stains support these findings, and it seems that variations in staining occur in different types of teeth. For example, the staining of the decalcified structures of unerupted, freshly erupted, and hypoplastic teeth differ from the reactions given in fully calcified and long erupted teeth.

A variety of views has been expressed as to the fate of this organic material when decay commences. Kraus (16) states that the organic substance combined with calcium is first lost as penetration by the acids proceeds. Barker (2) apparently has a similar concept when he describes the advance of caries along the enamel lamellae and a lateral spreading parallel with the striae of Retzius. C. F. and H. W. C. Bödecker (5) describe a proteolysis of the enamel matrix, which is ascribed to streptococci in spite of the fact that these organisms are only weakly proteolytic. Williams (30b) showed, in ground sections treated with silver nitrate, increased staining and apparently increased bulk of interprismatic substance as caries advances. He believed this to be due to the encroachment upon the substance of the enamel rod itself, the advance of the caries having taken place on the inside of the sheath. In an earlier publication, Bödecker (4b) described the bacterial destruction of the substance of the rod itself as preceding that of the

rod sheaths or cementing substance, which are apparently more resistant to bacterial lysis.

Concerning the importance of the rod sheaths in resisting caries, Williams (4a) has advanced the view "that the varying degree of resistance of enamel to the acids of caries may be due to variations of the chitin-like (?keratinous) content of the enamel, which may be of greater importance than variations of the mineral content." Gysi (11) discusses this possibility at length, suggesting that only under ideal conditions is this organic structure complete and fully hornified. In such a condition resistance to caries would be of the highest degree. Incomplete sheaths are occasionally formed resulting in an added liability to decay. The process of hornification requires as long as ten years for completion. This factor accounts for the high incidence of caries in young people up to the age of 20 years. The possibility that these hypotheses are significant seems to depend only upon the state of keratinization of the tooth protein, and the resistance of that keratin to the factors in decay. As there is proof of the keratinized state of the organic tissue in enamel, the properties of keratin and the changes occurring in it become important.

II. PROPERTIES OF KERATIN, ESPECIALLY RELATING TO BACTERIAL EFFECTS

Although the investigations into the nature of keratin do not seem to have been very exhaustive, certain interesting information has been recorded. Keratin is of wide distribution and is the insoluble protein in hair, horn, epidermis, and nerve sheaths. It has a protective function which may be increased by calcification. Keratin is resistant to such chemical reagents as acid and alcohol, but disintegrates in boiling strong alkalies. In this connection Rosebury (24) showed enamel keratin to be the least affected. Keratin is not digested by pepsin or trypsin, in fact the actions of these enzymes are used to separate it from other proteins. It is of the nature of an albuminoid rich in cystine, which accounts for a high sulphur content. The comparative indestructibility of keratin has long been taken for granted. Although the biological cleavages of many other proteins have been thoroughly investigated, there has been little consideration of this one in that connection. Keeser (15) has shown that keratin

passes through a dog's intestine unchanged, indicating its resistance to the action of pepsin and trypsin as well as of bacteria. To this property of resistance to bacterial destruction is attributed the protective action of the stratum corneum, although a vital bactericidal property has been described (1). The property of certain pathogenic fungi, epidermophytons and trichophytons, to live in the hair and skin, is the principal indication we have of any microbiotic relationships with the keratin of the body.

Castellani (7) describes the growth of "*Nocardia tenius*" (an actinomycete) in the condition of trichomycosis. Outside the body this relationship is more common. Ward (29) remarked upon the ability of several genera of fungi to grow on animal proteins such as horn, hair, hoof, and skin, and describes in detail one member of the "genus Oxygena" which he isolated from the horn of a cow. In this laboratory an aspergillus was isolated from keratin shavings where it had become established. Munter (22) reported the growth of seven soil actinomycetes on horn. Jensen (13) observed a similar growth of two soil actinomycetes on pure keratin prepared from horn meal by ether-extraction, and subsequent peptic and tryptic digestion. In the same paper he reported Benecke's observation in 1905 of the growth of an organism "*Bact. chitinovorus*" in a mineral solution with horn meal. It appears from this that with one exception the ability to destroy keratinous structures is found only amongst the fungi and the actinomycetes. There does not, however, appear to be any evidence proving that this ability is not shared by the commoner proteolytic forms of microörganisms. In an attempt to ascertain whether such a property exists, a few cultural experiments were performed.

Experimental

It was decided that the growth of an inoculated strain of organism, in a medium having no source of nitrogen other than keratin, would indicate that the nitrogenous compounds of this insoluble protein had been split off and utilized for the metabolism of those organisms. Attempts to produce growth under similar conditions had proved unsuccessful in the hands of Sperry and Rettger (26), this having been attributed to the non-elaboration of enzymes and to consequent inability of the bacteria to split the protein molecule. Merril and Mans-

field Clark (20) produced a gelatinase in a similar experiment, and suggested that magnesium and calcium were necessary for enzyme formation. Magnesium was absent from the media used by the first investigators. Jensen (13), however, demonstrated the lysis of keratin in the absence of calcium salts other than those combined in the protein. Stevens (27) and Waksman (28) both mention the production of proteolytic enzymes in protein-free media, the latter observer, however, noting an increased production when there was an organic source of nitrogen. For these experiments it was decided that Czapek's medium would be suitable, as it has been recommended by Waksman (28), and was similar to that used by Jensen (13) when experimenting with the same protein. The medium was the variation suggested by Henrici (12) as suitable for actinomyces, and has the following composition (grams): sucrose (30), sodium nitrate (2), dibasic potassium phosphate (1), magnesium sulphate (0.5), potassium chloride (0.5), ferrous sulphate (0.01), distilled water (1000).

The keratin was prepared from toe nails of cadavers. The nails were enucleated, cut longitudinally into strips about 2 mm. wide, and the basal portion containing the trypsin-lysable "young keratin" removed. These were then scraped with a knife to remove superficial contaminants and adherent tissue from the deep side, washed, and thoroughly dried between blotting paper. Sterilization was performed by autoclaving for fifteen minutes. In test cultivations with Czapek's medium it was found that with all the organisms except the molds, actinomycetes and perhaps *B. subtilis*, a more satisfactory growth was obtained when glucose was substituted for the sucrose of the original medium. Even then, however, growth was absent or negligibly slight in several of the inoculations. These glucose or sucrose Czapek-media were now prepared without any sodium nitrate, and to tubes of these media were added pieces of the prepared keratin. After a test incubation, these tubes of media were inoculated with strains of proteolytic organisms and organisms known to be present in the process of tooth decay. Either the sodium-nitrate-free glucose or sucrose medium was used, according to which had given the better indication of growth in the preliminary cultivations. The organisms used were *B. megatherium*, *B. mesentericus*, *B. subtilis*, *B. pyocyaneus*, *B. proteus*, *Lactobacillus acidophilus*, streptococci, staphylococci, streptothrix,

Act. hominis, *Act. bovis*, *Act. asteroides*, two molds (an aspergillus isolated from keratin, and *Epidermophyton inguinale*), five actinomycetes isolated from the mouth, and two unclassified proteolytic organisms from the same source. As there seemed a tendency towards sedimentation of the salts in these media, these inoculations were controlled against inoculated tubes of nitrogen-free media. Incubation at 37.5°C. was continued for as long as five weeks.

Results

It was found that growth persisted in only a few of the inoculated tubes. In the nitrogen-free, sucrose, Czapek-medium plus keratin, a strong growth occurred with *Epidermophyton inguinale*, aspergillus, streptothrix, a slight growth not persisting with *B. mesentericus*, *Actinomyces a*[2] and *b*[2]. In the nitrogen-free, glucose Czapek-medium plus keratin, a strong growth occurred with *B. pyocyaneus*, a weak growth with *B. subtilis*, *B. megatherium*, and *Act. asteroides*. All the other organisms gave no indication of growth as revealed by change or increased sedimentation of the liquid medium. From this it is indicated that the fungi and actinomycetes have a greater ability to utilize keratin as a source of nitrogen than the proteolytic bacteria. Of these latter, *B. pyocyaneus* alone showed active growth while *B. mesentericus* and *B. subtilis* gave little more than an indication of activity.

III. LYSIS OF ENAMEL KERATIN

(A) Using the above observations as an indication, an attempt was made to ascertain whether the enzymes of these active organisms would exert lytic action on the organic rod-sheaths of the enamel. For this purpose the epidermophyton, aspergillus and streptothrix were cultivated as above in Czapek's medium, with keratin as the only source of nitrogen. *B. pyocyaneus* and the streptothrix were cultivated in Douglas' broth, both with and without the presence of keratin. With the streptothrix, *B. pyocyaneus*, *B. subtilis*, *B. mesentericus*, *Act. asteroides*, *Act.* "*a*" and *Act.* "*b*," Douglas broth alone was used. After 8 days' growth for the vigorously growing forms and a longer period for the slower ones, phenol was added to inactivate the organ-

[2] Isolated from the mouth.

isms, and these cultures passed through Berkefeld filters. The filtrates obtained in this manner should contain enzymes formed by the growth and disintegration of the cultivated organisms. To test the action of these filtrates on enamel keratin, ground sections of freshly extracted and well scrubbed teeth were prepared. These were thoroughly cleaned in chloroform and alcohol, and mounted on glass slides in such a way that a portion of the enamel edge was quite free from the mounting material. On examination of this edge in water under a microscope, a rough sketch was made of a portion of the field to record the form and termination of several of the rod sheaths. After this record was made, these sections, immersed in the various bacterial filtrates, were kept in an incubator at 37.5°C. for 16 days during which period the filtrate was renewed three times. These sections were reexamined under the microscope, and the identical portion of the field compared with the recorded drawing, to determine whether there had been any removal of organic material.

By the use of oblique illumination and a subsequent staining by a silver nitrate-nitric acid method, it was possible to determine the exact organic and inorganic relationships of the whole edge. It was determined by these examinations that there was evidence of change in the organic substance only in those sections which had been subjected to the filtrates of the aspergillus and *Epidermophyton inguinale*. There was no evidence of change in the enamel edge or organic substance of the sections subjected to the action of the filtrates of *B. mesentericus*, *B. subtilis*, *B. proteus*, *Act. asteroides*, *Act. "a," Act. "b," B. pyocyaneus* (two filtrates), or streptothrix (two filtrates).

(B) Failure to produce organic changes in the preceding experiment with organisms other than the molds might be attributed to too short an exposure to the bacterial filtrates. To eliminate this possibility it was decided to subject the enamel to a direct and more prolonged exposure to bacterial action. For this purpose pieces of enamel were especially prepared from thoroughly scrubbed teeth. The dentin was completely removed from the whole or, as in later preparations, from half of the pulpal surface of these pieces of enamel, which were then allowed to stand in 70 percent alcohol for purposes of sterilization. After immersion in absolute alcohol and acetone, the enamel surfaces were painted repeatedly with an alcohol-celloidin mixture until only a

small area of the surface, about 3 mm. in diameter, remained exposed. The dentinal and all other portions were covered completely by the same method. The exposed surface of enamel had thus received as little treatment as possible. Before proceeding further it was determined positively that there was no spreading of celloidin onto this area. These pieces of enamel were then returned to 70 percent alcohol and from there placed directly into cultures of the organisms to the action of which they were to be subjected. At 10-day intervals the liquid media were pipetted out from these tooth preparations, and fresh media added. This long cultural period was considered advantageous in that it assured enzyme elaboration even should that be dependent upon bacterial lysis. This procedure was continued over a period of four months, when the cultures were inactivated with antiseptics, and the enamel was washed and the celloidin removed by solution in absolute alcohol. Any differentiation between the covered portions of the enamel was noted in each case. The enamel was then divided into two parts with a fine carborundum disc, the part with the supporting dentin being used for the preparation of a ground section, the other part from which the dentin had been removed being used for the preparation of decalcified sections by the celloidin-decalcifying method (4c). Each section prepared in this manner would, therefore, have a part of its edge which had been covered and a part which had been exposed to bacterial action.

Owing to difficulties and failures in section preparation, these results are not as complete as it had been hoped they would be. In the examination of the ground sections, special staining with silver nitrate showed the organic structures in sharp contrast with the calcified portions of the enamel. By use of oblique illumination, which could be altered to give a dark-field effect, it was possible to demonstrate the continuity of the enamel sheaths right to the edge of the enamel, either as black lines of precipitated silver or as bright bands of refracted light. The results of these observations, shown in *Table 1*, agree with the indications given in the previous ones. From all of these it would seem that calcified keratin, as it occurs in finger and toe nails, is not readily destroyed by bacterial action, but that the fungi seem to exercise this property in a higher degree. In addition it seems that the keratinous structures of the enamel are highly resistant against the

TABLE 1

Data showing action of cultures of microörganisms on enamel

ORGANISM	PREPARATIONS NO.	TIME OF EXPOSURE	APPEARANCE OF EXPOSED ENAMEL		
			Naked eye	Decalcified sections stained with hematoxylin and eosin	Ground sections stained with $AgNO_3$
		months			
B. mesentericus	2	4	Normal, clear, shining	Undifferentiated; whole section irregular	Rod sheaths continuous to edge
B. proteus	2	4	Slight loss of polish	Undifferentiated	" " " " "
B. subtilis	2	4	No definite change	No conclusion. Section irregular	" " " " "
B. pyocyaneus	2	4	No change	No conclusion. Section irregular	" " " " "
Act. "a"	2	4	Slight surface change. No loss of polish	No conclusion. Section irregular	" " " " "
Act. "b"	1	4	Slight dulling of surface	Undifferentiated. Whole surface irregular	" " " " "
Act. asteroides	1	4	Slight surface change	Edge entire	" " " " "
Staph. albus	1	4	No change	" "	" " " " "
Trypsin in 0.5% NaOH	1	4	No change		" " " " "
Lact. acidophilus	2	2 and 3	Surface decalcified and hollowed out		Surface irregular. Rod sheaths present

bacterial enzymes of the common proteolytic forms likely to occur in the mouth. This being so, it would seem highly probable that under certain circumstances the calcified portions of the enamel are destroyed before the organic structures. In an endeavor to test this hypothesis, examinations of enamel decay were undertaken.

IV. PROCESS OF ENAMEL DESTRUCTION IN THE MOUTH

Reports of examinations of enamel decay have formed a large part of the literature upon dental caries. All conclusions, with the possible exception of those of Bödecker (4b, 5) and Malleson (18) have been based upon considerations of ground sections alone. Of such, the findings of Williams (30a, 30b) are supported by the greatest mass of histological evidence, and can be accepted as authoritative. Bödecker (4b) in one place demonstrated the existence of rod sheaths after decalcification, but elsewhere suggested their destruction (5). Malleson (18) believed the prism cortex and the interprismatic substance were first destroyed. Williams (30b) showed the first penetration of decay to occur inside the enamel-rod sheaths. Although not definite, the weight of evidence here points to a destruction of the enamel rod in advance of the rod sheath. For the projected studies freshly extracted teeth, or teeth preserved for a short time in 70 percent alcohol, were used. These were washed with a brush and soap, and the surfaces examined for carious areas that had not penetrated to the dentin. Such surfaces were removed, the dentin hollowed out, and, after the use of Zenker's solution as a fixative, the pieces were passed through the acid-celloidin decalcifying method. In each case a drawing and description of the enamel fragment were made, and the subsequent placement in celloidin and paraffin so regulated that orientation was maintained throughout. In this manner it was hoped that it would be possible to know the exact type of enamel change under examination, and the nature of the surrounding tissue. In this manner over sixty specimens of enamel decay were prepared. Of these, however, no more than half yielded sections that could be oriented according to the recorded drawing and description. From these and the less successful preparations certain interesting observations were made.

Histological examinations

(A) *Staining.* Malleson (18) has remarked on the increased staining of the organic matrix of carious enamel. In these observations, marked variations in the reaction of section-preparations with haematoxylin-eosin, Gram-Weigert, and other stains, were noted. In fact such variations have been noted in different parts of the same section with no apparent relationship to any other tissue changes. The nature of these changes seems to be one of development rather than pathology, but if the organic structure of the enamel is important, in resisting caries, they are still of some significance. In these sections there was little evidence of increased staining about the carious lesions, although it is possible that such a reaction had been masked by the natural pigmentation which appeared in all cases.

(B) *Pigmentation.* A striking feature in all these section examinations was the brown pigmentation of the enamel-rod sheaths about the areas into which there had been carious penetration. Decalcified sections did not show how far into this pigmented area decalcification of the calcified rods had proceeded, but the study of ground sections indicates that pigmentation advances along the rod sheaths in advance of decalcification. It appears that this pigmentation originates from the products of decay rather than in any reaction or defense on the part of the enamel. This contention is supported by the intensity of this pigmentation in the center of carious lesions, its appearance on the surface-matrix of perfectly sound teeth, and its advance from the dentinal surface where caries of the dentin has destroyed any possible pulpal lymph-supply. On a few occasions it was found possible to remove this pigmentation by the action of chloroform, but this result was not consistent. This seems to indicate that more pigments than one are capable of producing this brown coloration, but that at least one of these is soluble in chloroform, a suggestion that it is a lipochrome and a possible product of bacterial activity.

(C) *Consolidation.* A further striking feature of the microscopic examination of these sections is what can best be described as consolidation of the rod-sheath spaces. In this condition the rod sheaths do not show as hollow tubes, but appear more in the nature of solid rods. In *fig. 1* this condition is shown with the enamel-rod sheaths in longi-

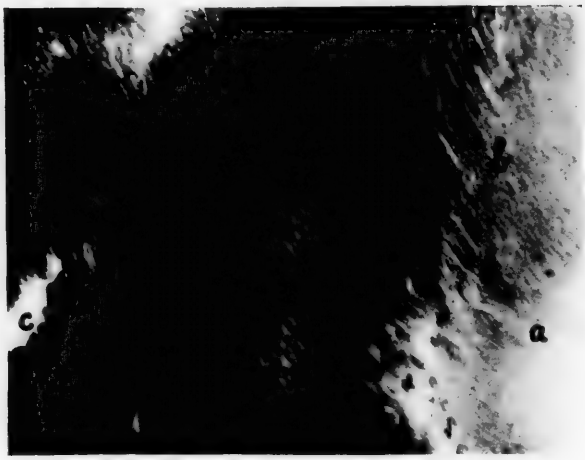

FIG. 1. DECALCIFIED ENAMEL SECTION. × 430

Shows consolidation and pigmentation of enamel matrix. (*a*).—Extension of pigmentation into normal enamel tissue ahead of consolidation. (*b*).—Consolidation terminating gradually and giving place to pigmentation. (*c*).—Dense consolidation and pigmentation, with persisting rod structure.

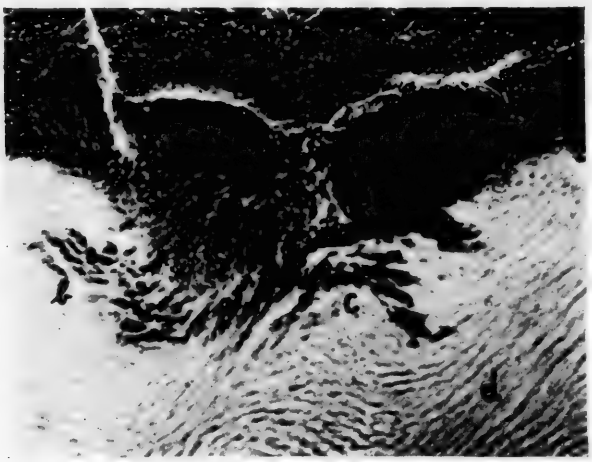

FIG. 2. DECALCIFIED ENAMEL SECTION. × 430

Caries (*a*) penetrating into normal enamel (*d*). Note sharp demarcation between normal and consolidated enamel. Consolidation is seen in individual rod sheaths at (*b*) in transverse section; at (*c*) in oblique section. Stained with haematoxylin and eosin.

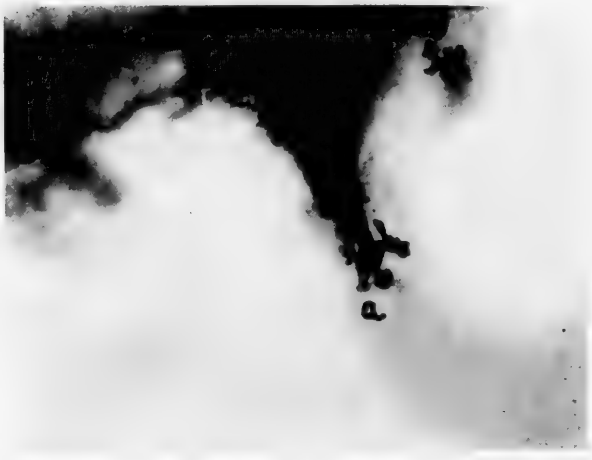

FIG. 3. DECALCIFIED ENAMEL SECTION OF HYPOPLASTIC ENAMEL. × 980

Organisms in enamel; at (*a*) separated by persistence of rod sheaths. Note uneven retention of Gram stain in parts of section; complete loss in others

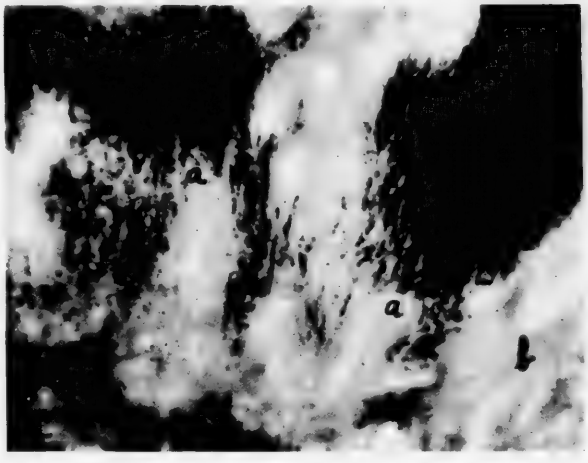

FIG. 4. DECALCIFIED ENAMEL SECTION. × 970

Penetrating organisms separated by persistent rod-sheaths at (*a*). At (*b*) normal enamel showing no details of structure. Stained with Gram stain and eosin.

tudinal section. In *fig. 2* it is demonstrated in both transverse and oblique section. This change in the enamel is sometimes sharply limited, groups of adjacent rods passing abruptly from the solidified to the normal hollow-rod structure. More generally, the change is gradual as shown in *fig. 1, b*. In the preparation of these sections it was strikingly evident that these consolidated portions of enamel stood the stress of decalcification and sectioning much more readily than normal enamel. In fact it was not at all infrequent to find these areas in perfect condition when the remainder of a section was completely

FIG. 5. DECALCIFIED HYPOPLASTIC ENAMEL. × 430

(*a*).—Surface. (*b*).—Typical space in center of enamel. In rest of field, see structure simulating rod sheaths, with marked increase of organic content and heavy staining. Compare with *fig. 2*. Stained with haematoxylin and eosin.

disordered. An illustration of Beust's (3) shows a similar persistence of a solidified, pigmented, carious area in enamel, which has otherwise been completely removed by the action of acid. This consolidation in decalcified enamel is too consistent in its appearance to be dismissed without some consideration of its possible significance. The lateral limitation of this change by the rod sheaths indicates that it can occur in one rod independent of its lateral neighbors. As there is no defensive or reflex nervous mechanism, it is evident that this change is completely passive in nature. Bacterial stains are taken up readily

by these solidified and pigmented areas, but it has been impossible to demonstrate bacterial forms in their depth. The Gram stain was held slightly by these consolidations, but it was never possible to clear the natural pigmentation to permit the observation of details of their composition. The use of stains designed to show Gram-positive and Gram-negative organisms in the tissue were no more successful. Thus, although there are indications, there is little beyond hypothesis to account for this characteristic appearance.

It is possible that when the enamel-rod sheaths are perfectly formed and fully keratinized, they are indestructible by bacterial action. Under these circumstances these organic structures are exposed to the fluids of the mouth together with products of bacterial decomposition, and it is conceivable that these cause a toughening of this tissue. This of itself would account for the increased durability of these consolidated areas of the enamel matrix shown in sectioning. Decalcification proceeds inside this organic tube for a considerable depth, but sooner or later the stage arrives at which the bacteria in the deeper part are deprived of their food supply, the readily available foods being utilized in the external portion of the column. The fermentable carbohydrates especially would be utilized here. The organisms in the depth of the hollow-rod sheath are, therefore, unable to produce the lactic acid necessary for further decalcification. Proteolytic organisms might persist in the deep parts, but products of metabolism will in time accumulate and inhibit further growth. The space in the rod sheath in time becomes filled with substances unaffected by the action of organisms, possibly the result of interaction of the products of bacterial decomposition, saliva, and enamel protein. Other factors depending upon changes of the enamel protein, influence of the saliva, or environmental changes of the tooth, may be important in the establishment of this apparently consolidated condition.

This hypothesis seems to explain fairly satisfactorily the occurrence of "caries sicca," or "arrested enamel-caries." When, however, the organic structure is imperfect or only partially keratinized, as sometimes seems to be the case, or where masticatory friction disrupts the organic continuity, caries advances without any limitation.

(D) *Caries.* The changes occurring in slow or arrested caries have been described above. On other occasions, where there is less

pigmentation or consolidation, it is possible to demonstrate bacteria in relation to the organic structures of the enamel. Such conditions are shown in *figs. 3 and 4*. Here it is noticed that the advance of the organisms is parallel with the direction of the rod sheaths. The depth of penetration is different in adjacent rod spaces, suggesting that neighboring rods act as individual and separate units. The lateral limitation of the bacteria is regularly observed, and in very few preparations have there been any indications of a lateral passage from one rod space to another. This observation supports the chain of evidence as to the relative chemical indestructibility of enamel keratin, and is in keeping with the observations of Bödecker (4a), Gysi (11), and Williams (30b).

(E) *Hypoplasia*. It was also noted that decalcified sections of enamel were much more readily obtained from hypoplastic than from normal or highly calcified enamel. This observation is in keeping with that of Mellanby (19), who pointed out that it was frequently possible to obtain sections of the organic matrix of hypoplastic enamel without the use of special decalcifying methods. It has been possible in these cases to demonstrate a definite change in the nature of the organic structure. There is an increased amount of organic material, which bears little resemblance to the normal enamel-matrix either in its structural elements or staining reactions. In other cases, however, there may be areas which simulate the rod-sheath formation of normal sections, but differ principally in that these sheath-like structures are smaller in diameter and less regular in appearance (*fig. 5*).

Descriptions of the histology of markedly hypoplastic enamel do not appear in dental literature. It has often been demonstrated, however, that stains readily penetrated poorly calcified enamel. This penetration has been generally used as a test for hypoplasia, and considered as indicative of a lower degree of calcification rather than an increase of the organic structures. In decalcified preparations this increased proportion of organic structure is obvious and it, therefore, assumes a greater importance in considerations of the processes of destruction of hypoplastic enamel. In this condition it is evident that the action of acid-producing organisms alone will not remove the entire enamel structure, but in addition there must be certain proteolytic agencies. What agencies are capable of this protein destruc-

tion has yet to be determined, especially in this condition where there seem to be variations in the nature of the organic element as revealed by differences in the staining reactions. Whether this varied tissue is easier or harder to destroy has not been determined, but its divergence from the usual keratinous nature would suggest the former. It is interesting, however, to note that sometimes teeth which are grossly hypoplastic exhibit a marked resistance to dental decay, especially when the irregular nature of the enamel surface is considered. Williams (30b) made a similar observation in animals and man, concluding that the resistance of the enamel depended on other factors besides its degree of calcification. It is suggested here that the state of the organic material of the enamel is another factor. It is possible that under certain circumstances this organic structure is of a nature which is not affected by proteolytic action and thus exerts a passive defensive action. This defense would differ with the structural perfection of the organic matrix, and it, therefore, seems liable to wide variations, for hypoplastic enamel exhibits marked structural differences. The full significance of this organic element cannot be stated as yet, but its existence and possible protective capacity should not be ignored.

V. SUMMARY

It has been shown that keratin is a relatively indestructible substance, and that biologically it is destroyed actively only by the action of certain fungi and actinomycetes.

By deduction and certain experimental evidence it has been shown that the keratin of the enamel shares this property of resistance to bacterial destruction.

In histological preparations the keratinous rod-sheaths have been shown to persist long after the rod substance itself has been destroyed, and have been shown to limit the lateral spread of enamel destruction.

It is suggested that the indestructibility of the organic element of enamel, possibly with other factors, at times limits the advance of enamel decay.

The increased proportion of the organic element in hypoplastic enamel, and variations in the nature of that element, are factors which influence the agencies of the destruction of these teeth.

Evidence has been presented which suggests that the organic element of the enamel acts as a passive defense against caries.

VI. BIBLIOGRAPHY

(1) Arnold, L. 1930 *Am. J. Hyg.*, xi, p. 345.
(2) Barker, F. J. 1931 *Jour. Amer. Dent. Assoc.*, xviii, p. 17.
(3) Beust, T. B. 1930 *Ibid.*, xvii, p. 1536.
(4) Bödecker, C. F. (a). 1927 (Discussion with J. L. Williams) *Dental Cosmos*, xix, p. 123.
(b). 1927 *Ibid.*, xix, p. 987.
(c). 1905 *Dental Review*, xix, p. 448.
(d). 1906 *Ibid.*, xx, p. 317.
(5) Bödecker, C. F., and Bödecker, H. W. C. 1929 *J. Dent. Research*, ix, p. 36.
(6) Cape, A. T., and Kitchin, P. C. 1930 *Jour. Amer. Dent. Assoc.*, xvii, p. 193.
(7) Castellani, A. 1928 *Arch. of Dermat. and Syphil.*, xvii, p. 194.
(8) Chase, S. W. 1929 *J. of Dent. Research*, ix, p. 288.
(9) Fish, E. W. 1928 *Dental Record*, xlviii, p. 289.
(10) Gies, W. J. 1926 *J. Dent. Research*, vi, p. 143.
(11) Gysi, A. 1931 *Dental Digest*, xxxvii, p. 661.
(12) Henrici, A. T. 1930 Molds, yeasts and actinomycetes, p. 28; John Wiley and Sons, New York.
(13) Jensen, H. L. 1930 *J. Agri. Sci.*, xxx, p. 390.
(14) Karshan, M. 1930 *J. Dent. Research*, x, p. 181.
(15) Keeser, E. 1929 *Deutsch. med. Wochenschr.*, lv (2), p. 1833.
(16) Kraus, A. 1931 *Deutsch. Monatschr. für Zahnheilk.*, xlix, p. 833.
(17) Leigh, R. W. 1923 *J. Dent. Research*, v, p. 197.
(18) Malleson, H. C. 1925 *Brit. Dent. J.*, xlvi, p. 907.
(19) Mellanby, May. 1930 Med. Research Council Reports; Diet and the teeth, Part I.
(20) Merril, A. T., and Clark, W. Mansfield. 1928 *J. Bact.*, xv, p. 267.
(21) Mummery, J. H. 1926 *Brit. Dent. J.*, xlvii, p. 473.
(22) Munter, F. 1913 *Cent. für Bakt. u. Parasit.*, xxxvi (2), p. 365.
(23) Orban, B. 1928 *Jour. Amer. Dent. Assoc.*, xv, p. 305.
(24) Rosebury, T. 1930 *J. Dent. Research*, x, p. 187.
(25) Rosebury, T., and Gies, W. J. 1929 *Ibid.*, ix, p. 299.
(26) Sperry, J. A., and Rettger, L. F. 1915 *J. Biol. Chem.*, xx, p. 445.
(27) Stevens, Marjory. 1930 Bacterial metabolism, p. 185; Longmans, Green and Co., New York.
(28) Waksman, S. A. 1918 *J. Bact.*, iii, p. 509.
(29) Ward, H. M. 1899 *Phil. Trans. of Royal Soc.*, cxci (B), p. 269.
(30) Williams, J. L. (a). 1923 *J. Dent. Research*, v. p. 27.
(b). 1923 *Ibid.*, p. 117.

INTERNATIONAL ASSOCIATION FOR DENTAL RESEARCH

Scientific Proceedings of the Pittsburgh Section
May 18, 1931[1]

LAWRENCE E. VAN KIRK, B.A., D.D.S., M.S., F.A.C.D., *Editor*

The meeting was held at the Dental School, University of Pittsburgh, May 18, 1931. *Chairman:* F. C. Friesell, D.D.S., F.A.C.D., President of the Section.

Scientific program

I. Researches on the nature, geographical distribution, and cause of mottled enamel. *H. E. Friesell*, D.D.S., B.S., LL.D., Sc.D., F.A.C.D. 117
II. The occurrence of fluorides in some waters of the United States. *H. V. Churchill*, B.A. 119
III. The cause of mottled enamel. *Margaret Cammack Smith*, M.A., Ph.D., *Edith Lantz*, M.A., and *Howard V. Smith*, M.S. 119

I. RESEARCHES ON THE NATURE, GEOGRAPHICAL DISTRIBUTION, AND CAUSE OF MOTTLED ENAMEL

H. E. Friesell, D.D.S., B.S., LL.D., Sc.D., F.A.C.D., Dental School, University of Pittsburgh, Pittsburgh, Pa.

The efforts of Black and McKay to determine the nature, endemic distribution, and cause of mottled enamel—and McKay's most recent publications—were discussed.[2] Emphasis was laid upon McKay's deduction as a dentist, published repeatedly from the circumstantial evidence, that an unknown factor associated with the drinking waters in endemic areas is the active cause of the lesion. Reference was also made to the fact that Alexander E. Bard, D.D.S., a former member

[1] Devoted to researches on the cause of mottled enamel.

[2] McKay: *Journal of Dental Research*, 1930, x, p. 561. Kempf and McKay: *Public Health Reports*, 1930, xlv, p. 2923 (reprinted in this issue: *Journal of Dental Research*, 1932, xii, p. 121; February.)

of the faculty of the Dental School of the University of Pittsburgh, and now practising dentistry in Tucson, Arizona—who was sensitive to the health needs of the people in the endemic areas—had induced the University of Arizona, in the summer of 1930, to undertake a study of the etiology of this condition. These remarks were introductory to the succeeding papers, from industrial and agricultural sources, which independently support McKay's general clinical deduction as to the source of the injurious agent.

[*Editor's note.*—At the suggestion of Dean Friesell, with whom Dr. Bard had been in communication, the following resolutions were adopted by the Research Commission, and by the House of Delegates, of the American Dental Association, at the annual meeting in Denver, Colo., in July, 1930 (*Transactions*, 1930, pp. 249–50):

"*Whereas*, there has been presented, to the Research Commission of the American Dental Association, impressive evidence of a condition that is endemic in Cochise County, Arizona, which results in the disfigurement and impaired oral functions of the children of that region; and

"*Whereas*, an appeal has been made to the American Dental Association, by the residents of St. David, Cochise County, and urgently supported by the Dental Society of Tucson, Arizona, and by the President of the University of Arizona; and

"*Whereas*, the limited appropriation made to the Research Commission, because of reduced funds available to the American Dental Association, does not permit this Association to provide financial help to carry on a study of this problem; and

"*Whereas*, the Research Commission recognizes the serious menace to the well-being of the people of the region mentioned, and several others, and the urgent need for a solution of the problem in the public interest;

"*Therefore Be It Resolved* that the American Dental Association strongly recommends that the problem be presented to the United States Public Health Service, or some philanthropic organization or individual, with an appeal for funds sufficient for a research to investigate this problem, in the hope of eliminating a condition that results in the early destruction of the teeth and in deformity of the mouth and face of a majority of the children born in that region; and that the American Dental Association strongly approves such a study."][3]

[3] The U. S. Public Health Service was unable to proceed with the proposed study.

II. THE OCCURRENCE OF FLUORIDES IN SOME WATERS OF THE UNITED STATES[4]

H. V. Churchill, B.A., Aluminum Research Laboratories, New Kensington, Pa.

McKay's studies, since 1915, led to the recurrent conclusion that the cause of mottled enamel is a factor associated with the potable waters of the endemic areas, but no specific common characteristic of these waters had been discovered. Shortly after the publication of the paper by Kempf and McKay,[2] A. W. Petrey, in this laboratory, discovered spectrographically the presence of fluorides in the deep-well water at Bauxite, Ark., which McKay had condemned as presumably causative of the mottled enamel in that district. Following Petrey's discovery, the author found fluorine in the potable waters in all the *endemic* areas examined, as indicated below in *parts of fluorine (as fluoride) per million*: Bauxite, Ark., 13.7; Colorado Springs, Col., 2.0; Kidder, S. D., 12.0; Lidgerwood, N. D., 11.0; Oakley, Idaho, 6.0. The relative severity of the enamel defect in these areas seems to follow the fluoride concentration. Waters from twenty-six *non-endemic* localities throughout the United States were either free from fluoride, or contained less than 1 part per million. These results strongly suggest but do not *prove* that fluorides are the causal factor. The author, recognizing this fact, raised this question: "What physiological effects may be produced by these fluorides?"

III. THE CAUSE OF MOTTLED ENAMEL[5]

Margaret Cammack Smith, M.A., Ph.D., Edith Lantz, M.A., and Howard V. Smith, M.S., Agricultural Experiment Station, University of Arizona, Tucson, Ariz.

In August 1930, at the suggestion of A. E. Bard, D.D.S., the authors began an effort to ascertain the cause of mottled enamel at St. David, Ariz. The problem was studied from the standpoint of possible anomalies of diet or drinking water. Experiments on dietary peculiarities were negative. Drinking water from St. David, with an adequate diet, had no perceptible effect on the incisors of rats, but given

[4] Published in full in this issue: *Journal of Dental Research*, 1932, xii, p. 141; February.
[5] Published in full in this issue: *Journal of Dental Research*, 1932, xii, p. 149; February.

this water after it had been concentrated by evaporation to one-tenth its volume, marked mottling of the enamel speedily followed. Previous workers having found that fluoride exerts deleterious effects on rat teeth, sodium fluoride was included among a group of mineral substances that were tested. All were negative excepting fluoride, which caused effects analogous to those induced by the concentrated water from St. David. The amount of fluorine in the potable waters of St. David ranged between 4 and 7 mg. per liter; non-endemic communities in Arizona, from 0 to 0.72 mg. per liter. Histological data will be obtained in the extensions of the study now in progress.

The cause of the "brown stain" associated with mottled enamel was not discovered. Fluoride does not cause the stain. Manganese, reputed to induce it, was absent from the drinking waters of St. David, where the stain is conspicuously present in the mottled enamel.

MOTTLED ENAMEL IN A SEGREGATED POPULATION[1]

GROVER A. KEMPF, M.D., *Surgeon*, AND FREDERICK S. MCKAY, D.D.S., *Consulting Specialist in Child Hygiene, United States Public Health Service*

Editor's note. For the convenience of dentists, three related important papers, in publications that are not commonly found in dental libraries, are reprinted here (pages 121–159) through the courtesy of authors and publishers. Of this group of papers on mottled enamel, the *first* (Kempf and McKay) is a somewhat condensed form of a report to the Surgeon General of the U. S. Public Health Service on conditions in an endemic district in Arkansas. (Reprinted from *Public Health Reports*, 1930, xlv, p. 2923; November.) The investigation of "some waters" described in the *second* paper (Churchill) was conducted, under the auspices of the Aluminum Company of America, primarily from an industrial standpoint as related to the production of aluminum. (Reprinted from *Industrial and Engineering Chemistry*, 1931, xxiii, p. 996; September. Read by the author at a meeting of the Pittsburgh Section of the International Association for Dental Research, Dental School, University of Pittsburgh, May 18, 1931,[1] and at a meeting of the American Water Works Association in Pittsburgh, May 26, 1931.) The *third* paper (Smith, Lantz, and Smith) describes the outcome of nutritional studies, under agricultural auspices, of dental effects of fluoride. (Reprinted, in a somewhat modified form, from *Technical Bulletin No. 32*, Agricultural Experiment Station, College of Agriculture, University of Arizona; June 10, 1931. Reported at a meeting of the Pittsburgh Section of the International Association for Dental Research, Dental School, University of Pittsburgh, May 18, 1931.)[1] The researches described in the second and third papers indicate, from two different points of view, that a constituent of drinking water (fluoride), in confirmation of the earlier conclusions of McKay, is the causative factor in the production of mottled enamel. Histological evidence has not yet been presented.

Mottled enamel has an interesting history. An article on this condition by Passed Asst. Surg. J. M. Eager, of the United States Public Health Service, then stationed in Naples, Italy, appeared in the *Public Health Reports* in 1901.[2] Eager noticed this condition of the enamel among Italian emigrants, particularly those coming from Pozzuoli, a community about five miles from Naples. This dental defect was called "denti di Chiaie," after Prof. Stefano Chiaie, who first described the condition. From Eager's description it is recognized as the enamel defect found also in various places in the United

[1] Proceedings of the Pittsburgh Section of the International Association for Dental Research, May 18, 1931: *Journal of Dental Research*, 1932, xii, p. 117; February.

[2] Eager: *Public Health Reports*, 1901, xvi, p. 2576; November 1.

States and in other countries, and now known as "mottled enamel." Incidentally, and curiously enough in the light of what is to follow later in this report, it was reliably reported to one of us (McKay) during an investigation of this Italian district in 1927, that Pozzuoli had changed its water supply and was no longer afflicted with this condition.

It was not until 1916 that further information appeared in the literature, when G. V. Black and F. S. McKay published a series of joint articles in *Dental Cosmos* on this condition. These men were the first in the United States to make an actual study of this enamel defect and to publish their results. The term "mottled enamel" was first used by Black as a descriptive name for the condition. His description is quoted as follows:

> The most essential injury occurring in this mottled enamel is the appearance of the teeth. * * * The teeth are of normal form, but not of normal color. When not stained brown or yellow, they are a ghastly, opaque white that comes prominently into notice whenever the lips are opened. * * * In many cases the teeth appear absolutely black. Mottled enamel is distinguished especially by the absence of cementing substance between the enamel rods in the outer fourth, more or less, of the enamel, and presenting great variety of color, rendering it totally different from anything else I have known.

The outer glazed enamel surface, or Nasmyth's membrane, is present and appears to be normal, except in what have been termed the "corroded" cases. The associated pigmented or stained phase of mottled enamel is called "brown stain." This brown stain does not occur in all cases of mottled enamel, and it seems to be limited to the labial surfaces of the upper incisors and cuspids. Chemical analysis of the "brownin," or pigment, has been made. It is said to be manganese. It is extremely rare to find mottled enamel on any of the temporary teeth. A very few cases have been observed in the various affected districts in which there was a slight flecking of the typical white spots on the enamel of the temporary molars, but never to our knowledge has the brown stain been observed on any temporary teeth. This typical brown stain can not occur unless the enamel bears the fundamental mottled defect; but not all teeth with mottled enamel

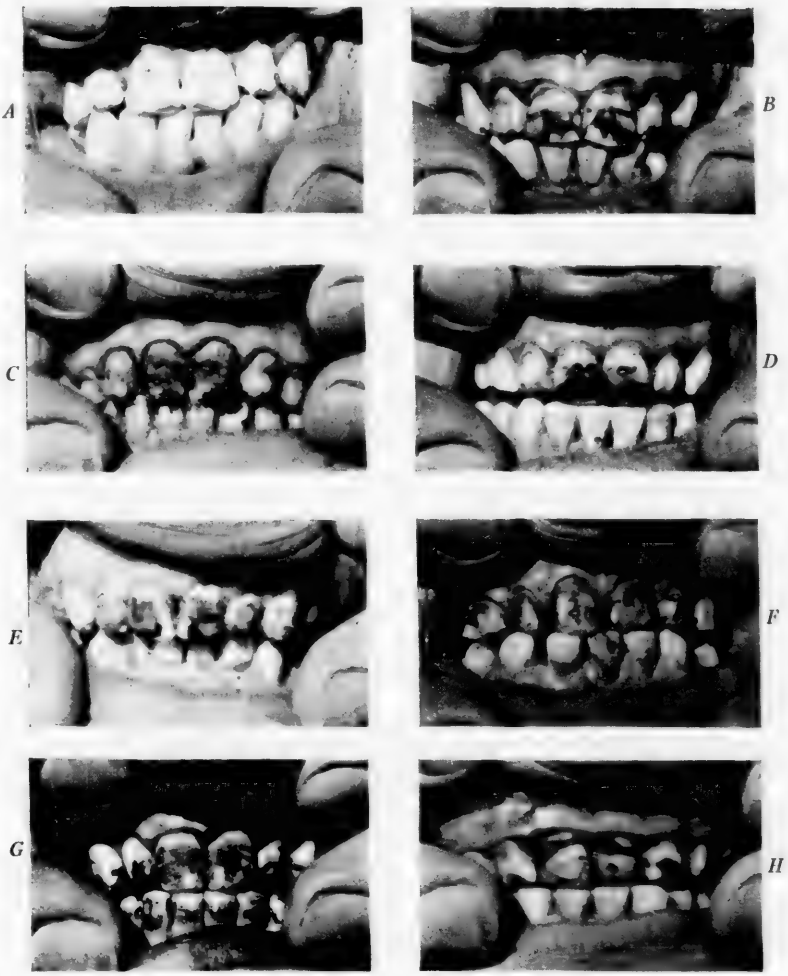

FIG. 1. TYPICAL ILLUSTRATIONS OF MOTTLED ENAMEL

A. Mottled enamel without stain. Note paper-white appearance of enamel.

B. Typical mottled enamel with brown stain. Teeth are well formed and stain is limited to labial surface of upper incisors.

C. Extreme type of mottled enamel, with corroded-like condition of enamel.

D. Stained and corroded teeth.

E—*H*. Additional cases of mottled enamel, showing stained and corroded condition of teeth.

are stained. McKay is of the opinion that the brown stain appears after the mottled teeth have erupted. Noyes, in his Dental Histology and Embryology, expresses the hypothesis that "the enamel rods and the cementing substance have a different origin, or are formed by different cells, and that pathological conditions may prevent the formation of one and not of the other." In Black's first description

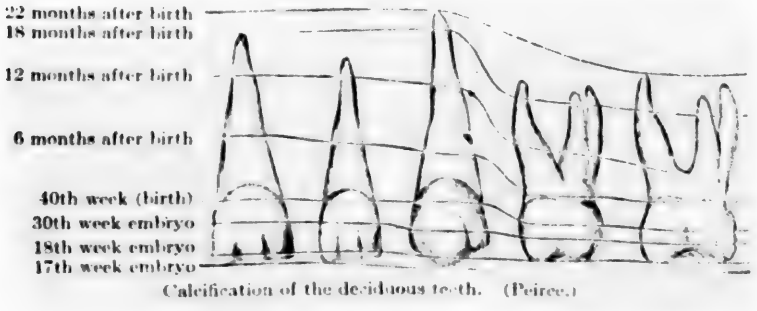

FIG. 2. Calcification of deciduous teeth. (Dental Pathology and Therapeutics, 7th edition; Burchard and Inglis.)

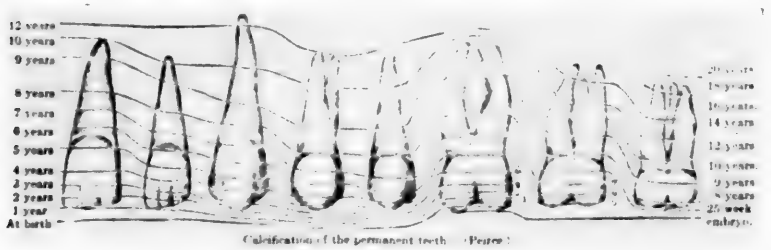

FIG. 3. Calcification of permanent teeth. (Dental Pathology and Therapeutics, 7th edition; Burchard and Inglis.)

of this lesion, it was made to appear that the enamel rods were themselves intact and of normal form and contour, but with the cementing substance absent. It has since been made evident, however, through the work of J. Leon Williams, that in some cases at least the rods themselves have been diminished in contour. The nature of the defect can readily be seen in the photographs of several typical cases presented herewith (*fig. 1.*)

McKay has investigated the condition in several affected districts in Colorado, Texas, Virginia, and Arizona. His results were published in *Dental Cosmos*, May to August, 1916. In 1917, he studied several endemic areas in South Dakota, and later extended his investigations to include areas in Idaho and California. Recently other centers have been reported in Illinois, North Dakota, and Minnesota. The condition occurs in various parts of the world, notably in Italy, certain of the Bahama Islands, Barbados, Holland, Cape Verde Islands, China, Mexico, Spain, Argentina, and other South American countries and in South Africa. Wherever it occurs the characteristics of the enamel defect are the same. Recently McKay noticed this condition in the photograph of a sheik of the desert, published in the National Geographic Magazine.

The disfiguring effect of mottled enamel can readily be appreciated. This condition is not subject to improvement or alteration through natural means, but only through a difficult operative procedure. When we also realize that every child born and reared in an endemic area is practically certain to have this disfigurement in some degree, we can readily understand that this is a problem worthy of solution. The time of development of the enamel of the deciduous and of the permanent teeth is of great importance in considering the etiology of mottled enamel. The accompanying *figures* (*2* and *3*) are taken from Burchard and Inglis, who used Peirce's table of calcification. The ages are subject to some variation. The mottling of the enamel in itself serves as an indication of the age when the enamel of the permanent teeth was developed in the child.

As previously stated it has been held that temporary teeth are free from this defect, but in the survey with which this report deals, some slight indications of mottling of temporary teeth were noted. In these cases, formation of the enamel had practically been completed at the time of birth or very soon afterward, but this must undoubtedly be subject to fairly wide variation. Some children might not have all enamel of the temporary teeth developed until several months or even a year after birth. After the protective influence of the placental circulation has been terminated, the enamel remaining to be developed is affected by the etiological factors in the endemic area. This could be particularly true in the premature baby. It follows, therefore,

that there may be no absolute reason against mottling of some of the temporary teeth. The following table from Burchard and Inglis[3] gives the approximate ages for the eruption of the permanent teeth:

First molars	5½ to 7 years	Cuspids	12 to 14 years
Central incisors	7 to 8 years	Second molars	12 to 15 years
Lateral incisors	8 to 9 years	Third molars	16 to 20 years or more
First bicuspids	10 to 11 years		
Second bicuspids	11 to 12 years		

For convenience we divide the permanent teeth into three groups, as did Black and McKay in their reports:

	Calcification		Eruption
First group:			
First molars	1 to 5 years		5½ to 7 years
Incisors	1 to 7 years	central	7 to 8 years
		lateral	8 to 9 years
First bicuspids	7 to 8 years		10 to 11 years
Second group:			
Second bicuspids	7 to 8 years		11 to 12 years
Cuspids	7 to 8 years		12 to 14 years
Second molars	5 to 9 years		12 to 15 years
Third group:			
Third molars	9 to 14 years		16 to 20 years or more

The endemic area with which this report deals was reported to the Public Health Service in 1927, and centers in the town of Bauxite, Ark., which was established in 1901 to provide homes and a social environment for the employees of a mining company. The original supply of water for domestic purposes came from shallow surface wells and a few springs. As the population increased, a larger supply was required. In 1909 a well 255 feet deep was drilled; later it was augmented by two other wells close by. Water from these wells was piped into the homes. Most of the shallow wells were then gradually

[3] Burchard and Inglis: Dental Pathology and Therapeutics, 7th ed., 1926; Lea and Febiger, Philadelphia and New York.

filled, and within the community proper the deep wells were the chief source of the water supply. This deep-well water has a disagreeable alkaline taste, and many of the families continued the use of spring water for drinking, especially during the warm months. The evidence collected during the examination of the children in the town school, consisting of the elementary grades and the high school, can be summarized as follows: (1) No cases of the enamel defect antedated the introduction of the deep-well water. (2) The oldest individual having this enamel defect was born about the time that the deep-well water was introduced. (3) All individuals who had used the deep-well water during any considerable period of enamel formation exhibited this defect. (4) No individual whose enamel had developed elsewhere exhibited the defect. (5) Certain individuals who were residents of this community and attending school there, but who actually lived beyond the distribution of the deep-well water and depended upon the original shallow wells, exhibited only normal enamel. Evidence supporting these postulates is presented in the tables appearing later in this report. In no district so far observed by one of the authors (McKay) has the evidence pointed so directly to a relation between the use of a certain definite water and the production of this enamel defect. It is necessary to consider the possibility, however, that some factor in the food supply, either before or after birth, bears some relation to the defect in question. In considering this point it is important to note that the enamel of the temporary teeth is formed almost entirely before birth, and is, therefore, directly dependent upon the pre-natal nutrition. These teeth, however, practically never show the defect. The permanent teeth do not commence to form until about one year after birth (average), and, hence, can not be even remotely related to the maternal nutrition.

The source of the food supply of these people is from a central store. The staple articles here, under the complexities of present-day civilization, are produced and manufactured elsewhere. In season certain articles are procured from surrounding truck farmers. It may be said that these locally grown products are reflective of the chemistry of the local soil. But the water from the shallow or surface wells is equally indicative of soil chemistry, and such wells are associated with normal enamel. The diet of the persons exhibiting the enamel defect

was in nowise different, except in the source of the water, from that of persons in the same environment who had escaped the defect. In the school children there was ample opportunity to observe all gradations of tooth eruption, from those in whom the first permanent teeth were just appearing, to those having all permanent teeth erupted. The children were requested to fill a questionnaire giving the place of birth and a history of places of residence since birth, with dates or ages at time of each change of residence. Each child was examined by McKay under natural illumination and without previous knowledge of the child's residence. The facts regarding age, time in Bauxite, etc., were verified by the child after the examination. This was later checked from the rental records of the mining company.

In no community previously examined by McKay were the facts relating to age and place and duration of residence so accurately recorded as in Bauxite, owing to access to the mining company's records and rent rolls, and the close coöperation given by the company's director of social relations among the employees. A total of 458 children from 5 to 18 years of age were examined in the schools of Bauxite. Mottled enamel of some teeth was found in 202 cases, or 44 per cent. In evaluating this percentage it is necessary to recall again the immunity of temporary teeth and also to consider the proportion of persons who, before becoming residents of Bauxite, had grown the enamel on such permanent teeth as were erupted at the time of the examination. If some local condition at Bauxite were responsible for the defect, such enamel would of course be normal. The complete picture could be revealed only by the facts regarding the condition of the unerupted permanent teeth of these native children, and similar teeth of the imported individuals upon which the enamel had been grown in Bauxite.

Table 1, presenting data on children who were born in Bauxite, gives the age of the individual at the time of examination, the number of children for each age, and the condition of the enamel of the first, second, and third groups of permanent teeth. There were 66 children in this group. Of these, 63 had permanent teeth erupted and 61 had mottled enamel of the first group of permanent teeth. Three children had no permanent teeth erupted, and only two children had normal enamel of the permanent teeth. The ages of the children of

this group ranged from 5 to 18 years; 43 of them had not erupted their second group of permanent teeth. The 23 children having their second group of permanent teeth had mottled enamel of these teeth. One child of 18 years, who had erupted the third molars, had mottled enamel of all his teeth. There were two children with normal enamel

TABLE 1

Condition of enamel of erupted permanent teeth[1] in children who were born in Bauxite, Ark., lived there all their lives, and used municipal deep-well water

AGE IN YEARS, AT TIME OF EXAMINATION	TOTAL NUMBER OF CHILDREN	FIRST GROUP				SECOND GROUP			THIRD GROUP		
		Mottled but not stained	Mottled and stained	Normal	Not erupted	Mottled	Normal	Not erupted	Mottled	Normal	Not erupted
5	1	1						1			1
6	10	7	1	[2]1	1			10			10
7	15	11	2		2			15			15
8	10	7	3			2		8			10
9	8	4	4			2		6			8
10	4	2	2			1		3			4
11	2		2			2					2
12	2	1	1			2					2
13	7	2	5			7					7
14	3	1	2			3					3
15	1		1			1					1
16	1		1			1					1
17	1			[3]1		1					1
18	1	1				1			1		
Total....	66	37	24	2	3	23		43	1		65

[1] Classification of permanent teeth indicated on page 126.

[2] City water available in house, but was not used for cooking or drinking.

[3] City water available in house, but spring water was used for drinking most of the time.

of the first permanent group. One of these was 6 years, and his second group of permanent teeth had therefore not erupted; the other was 17 years and showed only slight mottling of his second group of permanent teeth. The 14-year-old sister of this second case had definite mottling of all her permanent teeth. These two families had access to spring water as well as to the central supply.

Table 2 shows the condition of only the first group of permanent teeth, by ages of the children at the time of examination, and the ages between birth and 6 during which the children lived in Bauxite, and used the municipal deep-well water supply. A total of 77 children lived in Bauxite from birth to 6 years or more. Of these, 75, or 97.4 percent, had mottled enamel of the first group of permanent teeth in some degree. Of 16 children who lived in Bauxite from under 2

TABLE 2

Mottled enamel of first group[1] of permanent teeth among children in Bauxite, Ark.

AGES BETWEEN BIRTH AND 6 YEARS DURING WHICH CHILDREN LIVED IN BAUXITE AND USED MUNICIPAL DEEP-WELL WATER	ALL AGES	AGE AT TIME OF EXAMINATION															
		6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Birth to 6 or over:																		
Total examined	77	10	12	11	11	5	3	3	8	5	2	3	3	1				
Number mottled	75	9	12	11	11	5	3	3	8	5	2	3	2	1				
Under 2 to 6 or over:																		
Total examined	16	1	4	2	3	1	4	1										
Number mottled	16	1	4	2	3	1	4	1										
2 to 6 or over:																		
Total examined	21	2	4	1		3		2	3	1	1	1	1	2				
Number mottled	16	2	2	1		3		1	3		1	1	1	1				
3 to 6 or over:																		
Total examined	24	3	4	3	2	2	2		2		4	2						
Number mottled	12	1	1	2		2	2				2	2						
4 to 6 or over:																		
Total examined	26		3	2	5		4	7		2			1			1		1
Number mottled	10			2	2			5								1		
5 to 6 or over:																		
Total examined	22	3	2	3	1	1	1	1	3	1	3	3						
Number mottled	2					1		1										

[1] First group consists of first molars, incisors, and first bicuspids (page 126).

years to 6 or over, all had mottled enamel. Of 21 children who lived there from 2 years to 6 or over, 16, or 76 percent had mottled enamel. Of 24 children who lived there from 3 years to 6 or over, 12, or 50 percent, had mottled enamel. Of 26 children who lived there from 4 years to 6 or over, 10, or 38.5 percent, had mottled enamel. Of 22 children with residence in Bauxite from 5 years to 6 or over, only 2, or 9 percent, had mottled enamel in some degree of the first group of permanent teeth. The enamel of these teeth is developed from some-

time in the first year of life to about the sixth or seventh year. There is a definite relation between the time lived in Bauxite between birth and 6 years, and the condition of the enamel. The fact that two children who arrived in Bauxite at 5 years had defective enamel indi-

TABLE 3

Mottled enamel of second group[1] of permanent teeth among children in Bauxite, Ark.

AGES BETWEEN BIRTH AND 9 YEARS DURING WHICH CHILDREN LIVED IN BAUXITE AND USED MUNICIPAL DEEP-WELL WATER	ALL AGES	AGE AT TIME OF EXAMINATION													
		9	10	11	12	13	14	15	16	17	18	19	20	21	22
Birth to 9 or over:															
Total examined	28	2	1	3	3	7	5	2	2	2	1				
Number mottled	28	2	1	3	3	7	5	2	2	2	1				
Under 2 to 9 or over:															
Total examined	4			3	1										
Number mottled	4			3	1										
2 to 9 or over:															
Total examined	10		1		2	3	1		1	1	1				
Number mottled	10		1		2	3	1		1	1	1				
3 to 9 or over:															
Total examined	11		1	2		2		4	2						
Number mottled	9		1	2		1		3	2						
4 to 9 or over:															
Total examined	15	3		2	3		4			1			1		1
Number mottled	14	2		2	3		4			1			1		1
5 to 9 or over:															
Total examined	9			1		3	1	3	1						
Number mottled	5					3		2							
6 to 9 or over:															
Total examined	12			2	1	2	6			1					
Number mottled	7			2	1	2	2								
7 to 9 or over:															
Total examined	14		1	2	2	2	2	2		1		1			1
Number mottled	3		1	1		1									
8 to 9 or over:															
Total examined	8		3		1		1	1		1	1				
Number mottled			1												

[1] Second group consists of second bicuspids, cuspids, and second molars (page 126).

cates that the time of the development of enamel is subject to some variation. Of course there is a possibility that these children developed defective enamel before their arrival in Bauxite. The definite decrease in these percentages, however, is striking, ranging from 100

down to 9, and furnishes what seems to be the most reliable index to what is, after all, the remarkable uniformity in the rate of development of the teeth according to age.

Table 3 shows the condition of enamel of the second group of permanent teeth with the ages of the children at the time of examination and the ages between birth and 9 years or over during which they lived

TABLE 4

Condition of enamel of teeth of 14 persons with third molars erupted, Bauxite, Ark.

NUMBER OF YEARS LIVED IN BAUXITE—USED MUNICIPAL DEEP-WELL WATER	AGE ON ARRIVAL IN BAUXITE	PRESENT AGE	CONDITION OF THE TEETH			
			First permanent group		Second permanent group	Third molars
			Mottled	Stained	Mottled	Mottled
18	4	22	Normal	Normal	Mottled	Mottled
18	[1]	18	Slightly mottled	do	Slightly mottled	Slightly mottled
12	7	19	Normal	do	Normal	Mottled
11	6	17	do	do	do	Slightly mottled
10	8	18	do	do	do	Mottled
8	12	20	do	do	do	do
8	10	18	do	do	do	do
8	7	15	do	do	do	do
7	12	19	do	do	do	do
7	8	15	do	do	do	do
6	12	18	do	do	do	Normal
2	11	[2] 13	do	do	do	Mottled
[3]	[3]	17	do	do	do	Normal
2	13	[4] 15	do	do	do	do

[1] Birth.

[2] Now 17 years of age; attended Bauxite school from 13 to 17 years of age; living near Bauxite.

[3] Never lived in Bauxite but attended Bauxite school from 6 to 17 years of age; living near Bauxite.

[4] Now 19 years of age and living in Benton.

in Bauxite. A total of 28 children lived in Bauxite from birth to 9 years, and all of these children had mottled enamel of the second group of permanent teeth; 4 lived there from under 2 years to 9 or over, and all had mottled enamel of the second group; 10 lived there from 2 years to 9 or over, and all had mottled enamel of the second group. The percentages of defective enamel of the second group with

residence, in years, from 3, 4, 5, 6, 7, and 8, to 9 or over, were, respectively, 81, 93, 55, 58, 21, and 12.

The condition of the third group of permanent teeth is of great interest. This group consists only of the third molars, or "wisdom" teeth, which are supposed to calcify from about 9 years to 14. According to the evidence on the influence of environmental factors in the etiology of mottled enamel, the third molars of a child coming into an endemic district after the age of 8 or 9 would present the typical lesion and the remainder of the teeth (formed elsewhere) would be normal. We were able to examine 14 persons from 15 years to 24 who had lived in Bauxite two years or more during the time of calcification of the third molars. *Table 4* indicates the age on arrival in Bauxite, present age, number of years lived in Bauxite, and the condition of the enamel of the third molars. The first came to Bauxite at 4. He lived there 18 years. The enamel of the first group is normal; that of the second and third groups is mottled—a typical case. The next was born in Bauxite and lived there all his life. The enamel of all teeth was mottled. The third lived in Bauxite from his seventh to nineteenth year. His first and second groups of teeth are normal, but the third molars are mottled. The fourth arrived in Bauxite in his sixth year and has defective enamel of only the third molars. Why these first groups escaped in these two children is not clear. The next eight of these persons, who came to Bauxite when they were from 8 to 12 years of age, show normal enamel of the first and second groups, but defective enamel of the third molars, except in the case of one who arrived there in his twelfth year. One child who attended school in the village from his sixth to seventeenth year, but did not live in the village, had normal enamel. The other one arrived in Bauxite at 13, and the enamel was normal. The data seem to indicate that the enamel of the third molars was usually defective when the individual entered the endemic center any time up to 11 years of age.

This uniform peculiarity in the development of enamel of the third molars in individuals who come into these endemic districts after the age of 10 or 11 is considered by us as evidence pointing to the etiology of this condition. As has been shown in previous examinations, it can be stated that apparently any enamel in the process of formation during residence in an endemic district becomes definitely mottled,

owing to some influence that operates exclusively in such a district. It seems highly probable that the water and not the food supply of these districts contains the influence responsible for mottled enamel, since we can scarcely assume that an individual coming into such a district suddenly acquires a new (and damaging) food habit that deprives the growing enamel of precisely the elements, either in quantity or quality, necessary to its normal development. Such an assumption would imply that each individual had acquired identically the same detrimental food habit. It should also be stated that enamel grown

TABLE 5

Proportion of children with mottled enamel on first group of teeth, whose first group is also stained

PRESENT AGE OF CHILD	TOTAL NUMBER WITH FIRST PERMANENT GROUP MOTTLED	NUMBER MOTTLED BUT NOT STAINED	NUMBER MOTTLED AND STAINED	PERCENTAGE OF ALL MOTTLED CASES THAT ARE ALSO STAINED	PERCENTAGE BY GROUPS
All ages	167	94	73	43.7	
5	1	1			
6	15	14	1	6.7	10.0
7	24	21	3	12.5	
8	22	17	5	22.7	
9	19	8	11	57.9	38.9
10	14	6	8	57.1	
11	13	4	9	69.2	56.1
12	14	8	6	42.9	
13	14	6	8	57.1	
14	10	4	6	60.0	66.7
15 or over	21	5	16	76.2	

elsewhere (in non-endemic districts), and hence normal, undergoes no change whatever so far as observation shows, and certainly it never becomes in the slightest degree mottled upon exposure in an endemic region.

The question of the stain in the defective enamel has not been settled satisfactorily. This should not be confused with the mottling of the enamel, which is definitely known to occur during the developmental period. The proportion of mottled enamel that is stained increases from 10 percent among children at 6 and 7, to 67 percent among children at 13 years or older. Staining apparently develops and in-

creases with age. No one has ever removed the upper central permanent teeth before eruption, and the question of time of staining will never be definitely settled until this is done. A post-mortem would provide the opportunity, but it is a difficult matter to obtain consent for necropsy. There is no evidence in any community to indicate that the deleterious influence that causes mottled enamel has diminished or disappeared through any natural chemical or other alterations of its water supply. There is the possibility of artificial chemical alteration of the water through certain "treatments" employed commercially. Naturally such a procedure would assume knowledge of the exact chemical nature of the damaging ingredient, but such knowledge does not yet exist.

To serve as a check on the children of Bauxite, 124 children were examined in the school at Benton, a town about five miles from Bauxite. Of these 124 children, 103 were native to Benton (or other communities exclusive of Bauxite) and none presented anything but normal enamel. The remaining 21, ranging from 11 to 19 years, formerly lived at Bauxite for longer or shorter periods. Sixteen of this group lived in Bauxite for one year or more, and 11 had mottled enamel. The first, second, and fifth children included in *Table 6* were born in Bauxite, and left there at 12, 12, and 8 years of age, respectively. The enamel of the teeth of both groups was mottled. The third and ninth children arrived in Bauxite within the first two years of life. The enamel of both groups of teeth was mottled. Three children (6, 7, 10) arrived in Bauxite at 4 years and remained there until 11, 9, and 7 years, respectively. These children had normal enamel on the first group of teeth, but the second group was mottled. The twelfth child arrived at 5 years and left at 7. The enamel of the first group of teeth was slightly mottled, but that of the second group was definitely so. Four children (4, 8, 14, and 15) arrived at 7 years and left at 15, 12, 9, and 9 years, respectively. Only one of these (14) had mottled enamel—a typical case, the enamel of the first group of teeth being doubtful; that of the second group, definitely mottled. The other children had been in Bauxite only 1 year or less, or the time was unknown, and had normal enamel. McKay, without previous information, was able during the examination to pick every Bauxite child, by reason of the defect, from among the Benton children.

The effect of Bauxite environment on the enamel development in families, shown in *Table 7*, is of interest. One family with four children, aged 17, 15, 13, and 8, shows the following history: The 8-year

TABLE 6

Mottled enamel of teeth of children living in Benton, Ark., who formerly lived in Bauxite

CASE NO.	NUMBER OF YEARS LIVED IN BAUXITE AND USED MUNICIPAL DEEP-WELL WATER	AGE AT TIME OF EXAMINATION	AGE ON ARRIVAL IN BAUXITE	AGE ON LEAVING BAUXITE	CONDITION OF THE TEETH			
					First permanent group		Second permanent group	Third molars
					Mottled	Stained		
				years				
1	12	16	Birth	12	Sl. mottled	Normal	Mottled	Not erupted
2	12	14	do	12	Mottled	do	do	do
3	9	11	Under 6 months	9	do	do	do	do
4	8	18	7 years	15	Normal	do	Normal	do
5	8	13	Birth	8	Mottled	do	Mottled	do
6	7	14	4 years	11	Normal	do	do	do
7	5	18	do	9	do	do	Sl. mottled	do
8	5	17	7 years	12	do	do	Normal	do
9	4	19	2 years	6	Mottled	Sl. stained	Mottled	do
10	3	15	4 years	7	Normal	Normal	do	do
11	2	19	13 years	15	do	do	Normal	Normal
12	2	16	5 years	7	Sl. mottled	Stained	Mottled	Not erupted
13	2	16	9 years	11	Normal	Normal	Normal	do
14	2	15	7 years	9	Doubtful	do	Mottled	do
15	2	13	do	9	Normal	do	Normal	do
16	1	15	6 years	7	do	do	do	do
17	[1]	12	do	6	do	do	do	do
18	[1]	14	5 years	5	do	do	do	do
19	[1]	15	2 years	2	do	do	do	do
20		13	Unknown	[2]	Mottled	do	Mottled	do
21		13	do	[2]	Normal	do	Normal	do

[1] Less than 1 year.

[2] Unknown.

old was born in Bauxite, but had been away 19 months after he was one year old. The incisors showed an interesting distribution of the mottling in that in the central portion of the teeth, from mesial to distal, was a band of normal enamel bounded above and below by a

mottled area reflective of the periods spent in and away from Bauxite. The 13-year old was born in Bauxite, and showed mottled enamel of all her permanent teeth, with slight staining of the upper centrals. The 15-year old came to Bauxite at 2 years, left when he was 8, and returned when he was 10. All his permanent teeth were mottled, and the upper centrals were stained. The oldest child is now 17. He entered Bauxite when 4, left at 10, and returned at 12. His first group of permanent teeth were normal, having grown the enamel before coming to Bauxite. The second group, the enamel of which was grown in Bauxite, was definitely mottled.

Another interesting case is that of a girl of 12 who came to Bauxite

TABLE 7

Mottled enamel of teeth of children of same family, Bauxite, Ark.

	NUMBER OF FAMILIES HAVING THE SPECIFIED NUMBER OF CHILDREN WHO WERE EXAMINED					
	One child	Two children	Three children	Four children	Five children	Six children
No children with mottled enamel	82	32	13	5	1	1
One child with mottled enamel	69	4	4	2		
Two children with mottled enamel		30	3	5	1	
Three children with mottled enamel			7	3		
Four children with mottled enamel				3		
Five children with mottled enamel						1

between 3 and 4. The enamel of the *first* group of teeth showed a slight band of mottling near the gums, the remainder of the tooth being normal. The enamel of the *second* group was typically mottled; the band of mottled enamel on the *first* group was grown in Bauxite. The extraction of a loose temporary molar from the mouth of a native Bauxite child afforded an opportunity to observe that the underlying bicuspid was typically mottled prior to any exposure to mouth conditions.

The data gathered in this survey indicate that there is a specific agent or condition in the environment of the village of Bauxite which interferes with the development of the enamel of the permanent teeth, and is but a repetition of the information collected by McKay in his previous studies. This agent or condition is strictly limited to the

village, because children in the immediate vicinity of the village are not affected. It does not seem probable that this agent can be in the food, because the mode of life and the diet of these people are the same in the village as outside. It attacks the children of well-to-do families as well as those of lower economic status. Physical condition seems to be of no importance; so far as can be seen the only requirement is the use of water from the central deep-well supply.

The evidence brought out by this examination at Bauxite, together with similar evidence as to other districts, was responsible for the immediate abandonment of the then existing deep-well supply and the

TABLE 8

Results of analysis of deep-well water (rejected) and filtered water (substituted) at Bauxite, Ark.[1]

	DEEP-WELL WATER	FILTERED WATER		DEEP-WELL WATER	FILTERED WATER
	parts per million	*parts per million*		*parts per million*	*parts per million*
Total residue on evaporation	1,003.0	86.00	Iron and aluminium oxides	1.0	0.3
Loss on ignition	43.0	14.00	Calcium (Ca)	25.3	17.6
Fixed residue	960.0	72.00	Magnesium (Mg)	7.0	2.1
Chloride (Cl)	415.9	3.75	Sodium (Na)	344.6	9.6
Sulfate (SO_4)	39.6	15.70	Potassium (K)	9.2	3.4
Nitrogen as nitrate (NO_3)	0.3	0.03	Alkalinity (phenolphthalein)	1.0	0.0
Silica (SiO_2)	18.6	6.00	Alkalinity (methyl orange)	213.7	52.0

[1] Surgeon Kempf requested that these waters be examined particularly for manganese. Traces of manganese were found in both of these samples of the order of magnitude of approximately 0.04 parts per million.

substitution of another source. The absence of this enamel defect in the children native to the neighboring town of Benton led to the use of water from the same source, the Saline River, and adapting it to the domestic needs of Bauxite. This involved piping the river water about four miles, and passing it through a filtration plant before turning it into the distributing pipes. This change was effected shortly after the time of this study. Bauxite is apparently the second community in the world to abandon an otherwise satisfactory water supply and substitute another solely because it apparently caused this dental defect. The first community to make such a change was Oakley, Idaho, an account of which was given in *Dental Cosmos* (September, 1925). The fairly stable populations of these localities will, within

six or seven years, afford an opportunity to observe the influence of the new water supply upon enamel grown subsequent to the change, and to determine the validity of the indictment of the former supply. No other material changes in the food habit or mode of living are likely to occur. A second survey will be undertaken at an appropriate time in each of these two communities.

A report of analyses of samples of both the old deep-well water and the new filtered water of Bauxite, made by the Division of Chemistry of the National Institute of Health, is given in *Table 8*. The determination of the manganese content of these waters is held to be of

TABLE 9

Results of analysis of water from various endemic districts

(Parts per million)

CONSTITUENTS	MINE WATER AT V	LAWSON RANCH WELL WATER	SCHOLE'S WELL	MINE WATER AT E	SIGLE RANCH SPRING	CITY WATER AT L	CITY WATER AT B
Sodium	276.77	207.80	242.70	37.12		3.30	6.21
Potassium		3.35	6.44		11.05		
Calcium	89.75	31.80	33.31	74.50	21.32	5.70	23.44
Magnesium	27.36	37.75	33.60	16.71	5.41	1.70	Tr.
Iron	Nil		3.35	Tr.		0.49	1.95
Aluminum	2.74						
Chlorin	47.37	31.00	51.00	14.17	8.31	7.29	4.82
Sulphuric acid	651.49	142.40	250.00	104.66	46.80	7.10	
Carbonic acid	216.78	615.00	530.00	239.60	22.80	15.30	
Silicic acid	16.68	21.65	18.12			7.50	6.45

value only with regard to the possibility of its being the factor accounting for the "brown stain" as noted above. It is not thought to be associated with the general disruption of the orderly or normal arrangement of the integral enamel structure as indicated by the term "mottled." It will be noted that there is a decided difference in the chemical structure of these two waters, principally in that the deep-well water is a sodium bicarbonate water, while the filtered water is a calcium bicarbonate water, as computed by Mr. W. D. Collins, chemist in charge, quality of water division, U. S. Geological Survey.

Table 9 is taken from an article published in *Dental Cosmos*, in 1916, by Black and McKay, showing analyses of waters from various en-

demic districts studied at that time and is inserted here for comparison. These analyses throw no light whatever on the probable causal agent. The enamel defect occurs where waters of extremely low as well as of extremely high mineral content are used.

It would seem logical and would be highly desirable that animal experimentation be undertaken in some pronounced endemic district under strict water and dietary control, to ascertain definitely whether the water carries some deleterious agent, or lacks something necessary for the normal growth of the enamel. In this respect it is again brought out, as in previous publications by one of us (McKay), that thus far in this investigation this lesion of the enamel had never been reliably reported as occurring in animals. Various animal feeding experiments have been conducted by Howe and Pierle and others, in which structural damages have been brought about in bony and dental tissues by severe dietary restrictions in the experimental animals, but the reproduction of this specific lesion of the enamel in any of these experiments has never been accomplished. There is some question, then, as to what animal could be most successfully used for this purpose. Kempf suggests the pig; possibly the dog. Without any definite indication it would seem that the experimental animal would best be one in which the period of enamel growth was projected over a period of time corresponding as nearly as possible to that of the human.

No definite conclusions can be deduced at present other than that this enamel dystrophy occurs in certain areas in the United States, and the etiological factors seem to be definitely associated with the water supply of these areas. Exposure of a child, during permanent enamel growth, to the environmental factors in an endemic area appears almost certain to result in the development of mottled enamel.

The findings in this report have been compiled largely by one (Kempf) who has approached this survey from the standpoint of the trained investigator into conditions responsible for general human pathology, with no prejudice or influence from the dental standpoint.

BIBLIOGRAPHY[4]

[4] The bibliography, as given in the original in *Public Health Reports*, was identical in content with that published a month earlier by McKay in the *Journal of Dental Research*, 1930, x, p. 566; October. The most important additions to that bibliography are those presented in the two papers that follow: Churchill, p. 141; Smith, Lantz, and Smith, p. 149.—[*Ed.*]

THE OCCURRENCE OF FLUORIDES IN SOME WATERS OF THE UNITED STATES[1]

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Investigators of the dental defect known as mottled enamel seem to agree on two points: the defect occurs in certain geographical areas, and the causal factors seem to be associated with the water supply of those areas. Reference to the complete bibliography on the subject compiled by Kempf and McKay[2] shows that no specific common characteristic of the waters from affected areas has been discovered. Shortly after the publication just mentioned, A. W. Petrey of this laboratory spectrographically discovered the presence of fluorides in deep-well water from Bauxite, Arkansas. These deep wells were formerly the source of water used by individuals who show the characteristic dental defect known as mottled enamel. Several months prior to the investigation covered in the report of Kempf and McKay the deep-well supply at Bauxite was abandoned in favor of another supply, which has since been found to be free from fluorides.

The presence of fluorides was first revealed by means of the spectrograph. Substances containing both calcium and fluoride show a characteristic spectral band having its head at 5291Å. and which is degraded towards the infra-red end of the spectrum.[3] The spectrum obtained from Bauxite deep-well water is shown in *fig.* 1. The definite

[1] *Editor's note.*—This paper is an important contribution to the etiology of mottled enamel. It was presented at a meeting of the Pittsburgh Section of the International Association for Dental Research, Dental School, University of Pittsburgh, May 18, 1931 (*Journal of Dental Research*, 1932, xii, p. 119; February). See the "Editor's note" on p. 121 of the preceding paper (Kempf and McKay); also the succeeding paper (Smith, Lantz, and Smith). Reprinted from *Industrial and Engineering Chemistry*, 1931, xxiii, p. 996; September.

[2] Kempf and McKay: *Public Health Reports*, 1930, xlv, p. 2923; November 28; also *Journal of Dental Research*, 1930, x, p. 566; October.

[3] Papish, Hoag, and Snee: *Industrial and Engineering Chemistry*, 1930, *Anal. ed.*, ii, p. 263.

and specific character of the 5291Å. band of calcium fluoride is given in *fig. 2*, which shows the spectra obtainable from a variety of calcium salts. *Only those salts that contain both calcium and fluoride show the characteristic band indicated by the limiting lines in the cases of the spectra of calcium fluoride and that of a mixture of calcium oxide and aluminum fluoride.* Following the discovery of fluorides in Bauxite deep-well water, the author secured samples of water from other localities where the defect occurs. These localities were Colorado Springs, Col.; a well near Kidder, S. D.; a well near Lidgerwood, N.D.; and Oakley, Idaho. Spectrograms of the water from these localities are shown in *figs. 3 and 4*. The presence of fluorides is definitely shown in all cases. When the residues from these waters, after evaporation, were tested qualitatively for fluorides by etching methods,[4] positive tests resulted in all cases. While the etching produced in some cases is slight, nevertheless in all cases it was demonstrably positive.

Quantitative estimation of fluorine is fraught with difficulty. In the author's opinion, determinations of fluorine even with the best available methods tend to give low results. For the determination of fluorine in the samples herein considered, recourse was taken to a method of Fairchild.[5] Since this method was worked out for particular use on phosphate rock, it was necessary to adapt it to the analysis of water. The method, as finally used in the work covered in this paper, was as follows:

Pipette 100 cc. of water in a 250-cc. glass-stoppered Erlenmeyer flask, add 1 drop of methyl red, and 1.0 *N* hydrochloric acid dropwise until acid. Add 10 cc. of 20 percent sodium chloride solution. Filter, wash, and discard any precipitate. Add an excess of 0.08 *M* ferric chloride over that required for completion of the reaction,

$$FeCl_3 + 3NaF = FeF_3 + 3NaCl$$

Five cc. is the proper amount for fluorine content from 0.001 to 0.01 gram. Add 2 cc. of 1.0 *N* hydrochloric acid and 10 cc. of 5 percent potassium iodide solution, and stopper the flask. Immerse it in a water-bath at a temperature of 38 ± 1°C., and allow it to remain in the bath 30 minutes. Iodine is liberated by the ferric chloride in excess of that required to react with the fluorine present. Quickly cool the flask, and titrate the iodine with standard thiosulfate solution, using starch as indicator. Simultaneously carry through a control sample with 100 cc. of distilled water and the quantities of reagents used in the analysis.

[4] Scott: Standard methods of chemical analysis, i, p. 212, 1925; D. Van Nostrand Co., New York.

[5] Fairchild: *Journal of the Washington Academy of Sciences*, 1930, xx, p. 141.

The difference in thiosulfate consumption between the control and the sample represents the ferric chloride consumed in the reaction with fluoride. If the thiosulfate solution contains 4.354 grams of the crystallized salt per liter, it will be equivalent to 0.001 gram of fluorine per cc.

If the fluorine content shown by the analysis is very low, repeat the analysis, with a larger sample. Evaporate this to 100 cc. in platinum. Do not allow the solution to become strongly concentrated during the evaporation, lest hydrofluoric acid be lost.

Application of this method to various samples from endemic areas yielded the following results:

LOCATION OF SAMPLE	FLUORINE AS FLUORIDE
	p.p.m.
Deep well, Bauxite, Ark.	13.7
Colorado Springs, Colo.	2.0
Well near Kidder, S. D.	12.0
Well near Lidgerwood, N. D.	11.0
Oakley, Idaho.	6.0

It is well to emphasize the fact that no precise correlation between the fluoride content of these waters and the mottled enamel has been established. All that is shown is the presence of a hitherto unsuspected common constituent of the waters from endemic areas. However, it is of interest to note that apparently the relative severity of the defect in these various areas seems to follow the fluoride concentration. Since the occurrence of fluorides in potable waters has apparently not been widely studied, a survey of some municipal supplies in the United States—all from localities where mottled enamel does not occur—was undertaken, with the results for distribution of fluorides summarized below:

A. *Fluorides present* in the water-supply: Birmingham, Ala.; Buffalo, N. Y.; Cincinnati, Ohio; Cleveland, Ohio; Davenport, Iowa; Detroit, Mich.; E. St. Louis, Ill.; Indianapolis, Ind.; Kansas City, Mo.; Los Angeles, Cal.; Milwaukee, Wis.; Minneapolis, Minn.; Peoria, Ill.; Pittsburgh, Pa.; San Francisco, Cal.; Toledo, Ohio.

B. *Fluorides absent* from the water-supply: Albany, N. Y.; Atlanta, Ga.; Boston, Mass.; Chicago, Ill.; Dallas, Texas; Fairfield, Conn.; Newark, N. J.; New York, N. Y.; Philadelphia, Pa.; Washington, D. C.

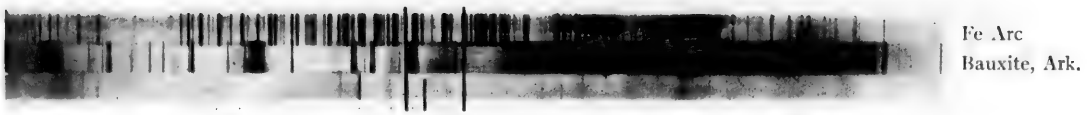

FIG. 1. Spectrum of deep-well water at Bauxite, Ark. (endemic area)

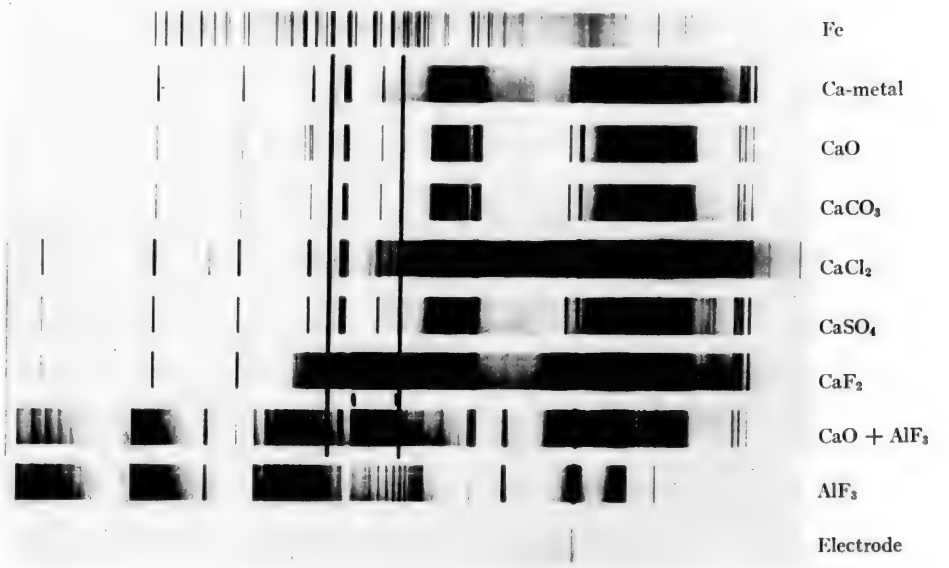

FIG. 2. Spectra obtained from a variety of calcium salts

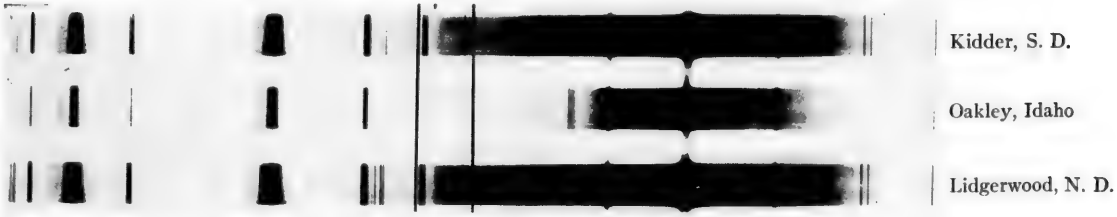

FIG. 3. Spectrograms of various waters from endemic areas

FIG. 4. Spectrogram of spring water at Colorado Springs, Col. (endemic area)

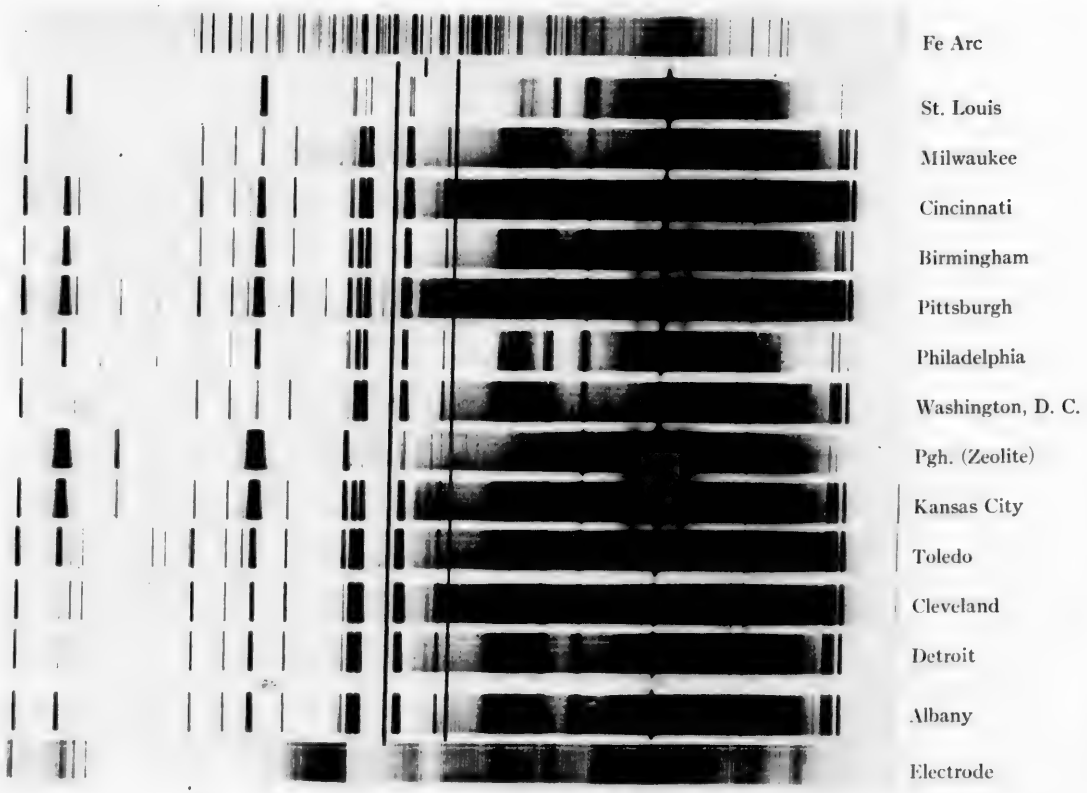

FIG. 5. Spectrograms of various waters in the United States

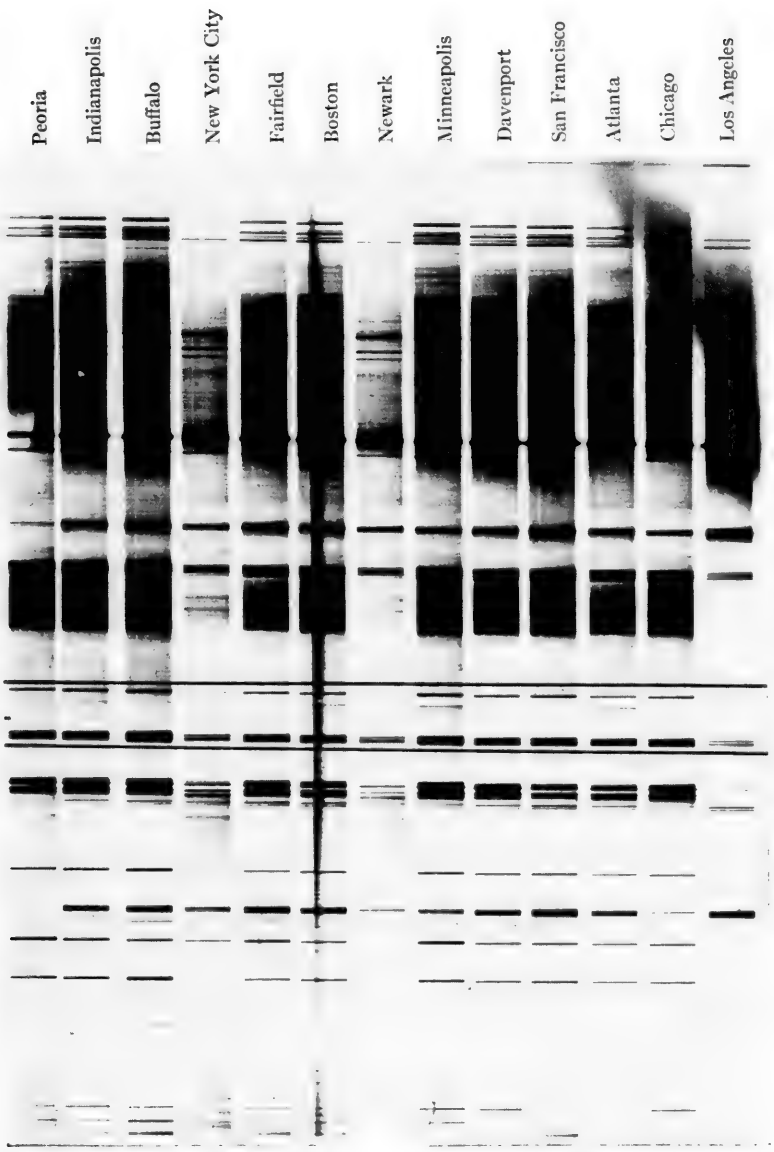

FIG. 6. Spectrograms of various waters in the United States

Figs. 5 and *6* show spectrograms of the various waters. The fluorine content in all positive cases in group A, above, was found by quantitative examination to be *less than 1 part per million*. The geographical distribution of the waters tested is shown in *fig. 7*, which brings out the interesting fact that traces at least of fluorides are to be expected west of the Appalachians. In no case were fluorides found in waters east of the Appalachians.

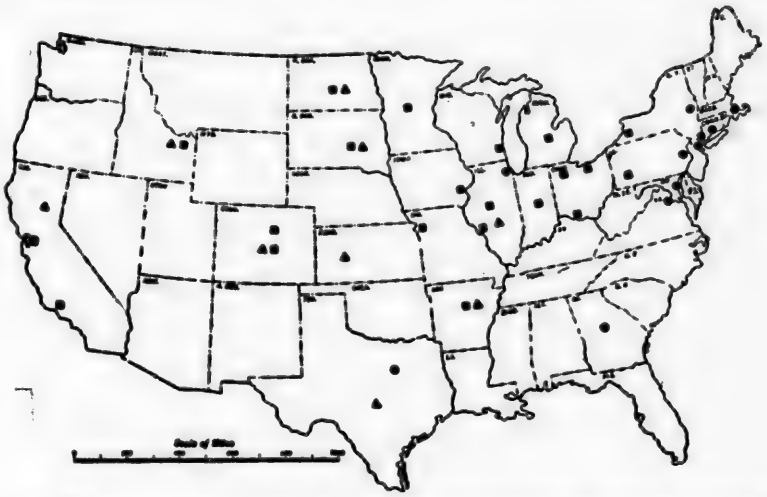

FIG. 7. Map showing geographical distribution of tested potable waters in the United States.

■ = Fluorine present. ● = Fluorine absent. ▲ = Mottled enamel known to occur.

Again it is emphasized that no causal connection has been established between the occurrence of fluorides in these waters and the mottled-enamel defect. However, McClure and Mitchell[6] report the profound influence of fluorine in the diet upon bone structure. This effect is either the deposition of an apparently abnormal constituent in the bones, or the abnormal deposition of a non-calcium constituent as evidenced by an increase above normal in the ash of the bones. They also specifically state that fluorine in the diet at certain levels has a peculiar effect upon the development of teeth. Pending establish-

[6] McClure and Mitchell: *Journal of Biological Chemistry*, 1931, xc, p. 297.

ment of causal connection between fluorine at certain concentrations in water and the mottled-enamel defect, water chemists might well give attention to the problem of the control of fluoride concentration in drinking water. Two questions are raised by this discovery of unsuspected amounts of fluorine in drinking water. First, what physiological effects may be produced by these fluorides? Second, what can water chemistry contribute to the concentration control of fluorides?

Acknowledgment is given to Dr. F. S. McKay of the Public Health Service for help in securing water samples from endemic areas.

THE CAUSE OF MOTTLED ENAMEL[1]

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Mottled enamel, a tooth defect first reported in the United States by Black and McKay in 1916, is endemic in certain communities in Arizona as well as in many other sections in the United States, Europe, South America, and South Africa. The characteristics of this defect are now well known to the dental profession. It is chiefly distinguished by the presence of dull, chalky-white or paper-white areas distributed irregularly over the surface of the enamel. In many cases the whole enamel surface presents this dead white, unglazed appearance. Frequently the enamel is badly pitted and corroded, and is structurally weak, tending to chip off. Mottled teeth may or may not be stained, but the staining is a secondary phenomenon. The

[1] *Editor's note.*—This paper, an important contribution to the etiology of mottled enamel, was presented at a meeting of the Pittsburgh Section of the International Association for Dental Research, Dental School, University of Pittsburgh, May 18, 1931 (*Journal of Dental Research*, 1932, xii, p. 120; February). The paper, including the experimental data upon which it was based and a bibliography, has since been published as *Technical Bulletin No. 32*, Agricultural Experiment Station, University of Arizona (June 10). The "Foreword" in that Bulletin reads as follows: "It is the purpose of this bulletin to present a preliminary report of the experimental work done to discover the cause of mottled enamel, a defect of human teeth. The investigation was begun under a Purnell project which was approved in June, 1930. Production of mottled enamel on the teeth of the experimental animals was accomplished in February, 1931. Preparation of this manuscript was begun at that time; but realizing the usual delay of publication, a note entitled "The Cause of Mottled Enamel" was sent to *Science*, on April 27, 1931. The data upon which both the note to *Science* and a paper read by request before the University of Pittsburgh Section of [the International Association for] Dental Research were based, are included in this paper. Since sending the paper to *Science* our attention has been called to an item in the News Edition of April 10 of the *Journal of Industrial and Engineering Chemistry* outlining a discussion following a paper presented by H. V. Churchill before the Section of Water, Sewage, and Sanitation Chemistry of the American Chemical Society at the Indianapolis meeting, March 30–April 3, 1931. The presence of fluorine in waters from localities affected with mottled enamel was reported."

general tendency for the stain to follow the lip line suggests that exposure to air and light may be a factor in its production.

The prevalence of mottled enamel in St. David, Arizona, a small settlement 63 miles southeast of Tucson in the San Pedro Valley, was brought to the attention of the University of Arizona by A. E. Bard, D.D.S., of Tucson, in August, 1930, and experimental work was started by the writers shortly afterwards to discover the cause of this disfiguring tooth defect. Whereas the writers have compiled data of mottled enamel in several other sections of Arizona—Sacaton, Pima, Thatcher, Willcox, Florence, etc.—St. David lent itself admirably to an investigation of the probable etiological factors. The data presented in this paper are chiefly concerned with a study of conditions in this community. Photographs of typical cases of mottled enamel in the school children of St. David are shown in *fig. 1*.

In order to establish the percentage incidence of mottled enamel in St. David, a survey of existing conditions was made with the aid of Dr. Bard, and a record thereof made for every boy and girl in the elementary grades and high school. Subsequently every home in St. David was visited and similar information obtained for each member of the family. It was found that, with the exception of one family of three children living 7 miles south of St. David and the sister-mothers of two other St. David families, every person born and reared in St. David, or coming there at an early age, showed mottling in varying degrees in every permanent tooth. Again, those coming into the community for continued residence after the age of 6 to 7 possessed the characteristic mottling only on those teeth which erupt during the ages from 8 to 12 (bicuspids, cuspids, and second molars). It appeared that exposure of the child to environmental factors in St. David during the years of formation of the enamel of the permanent teeth was certain to result in mottling.

The theory of Carl Fossum, that common diseases of childhood occurring as the permanent tooth is erupting is the causative factor of mottled enamel, was disproved by records of the age of occurrence of measles, chicken-pox, mumps, whooping cough, etc., which showed no significant difference between the members of the family possessing mottled enamel and those who did not. Although the work of Mellanby and others has shown clearly that dental defects are often caused by

dietary deficiencies, it did not seem logical to the writers to believe that poor nutrition was the sole cause of mottled enamel. It is impossible to believe that, with a change in residence, the family dietary habits could change so radically as to produce the gross defects that appeared in all the members of a family reared in St. David, and not in other members of the same family who came to St. David in their later years. As very little of the food supply is produced in St. David, a possible effect of soil deficiency or presence of a toxic factor was excluded in the search for the cause of mottled enamel. Circumstantial evidence for the conviction of the water-supply has been repeatedly presented by Dr. Frederick S. McKay. Here again it seemed as though the water-supply was the most logical place to look for the cause of the trouble. For the past 42 years St. David has had artesian water, but such water is not in itself to be suspected as the cause—a view once held by McKay—for St. David is the only endemic Arizona community known to the writers which possesses an artesian water supply. St. David water is not a highly mineralized water. It contains a relatively small amount of dissolved salts (160–190 parts per million)—less than half that contained in Tucson City water, and very much less than the amount in most other Arizona waters from either endemic or non-endemic sections. Routine analysis of St. David and other waters for calcium, magnesium, chlorides, carbonates, bicarbonates, etc., showed nothing significant.

With the probability before us that potable water was responsible for the mottled enamel, a series of experiments was planned to ascertain the facts in this connection. In spite of the observed absence of mottling of the teeth of domesticated animals in St. David, and reports of other investigators that mottled enamel had never been seen except in the mouths of humans, experimental production of mottled enamel in laboratory animals, rats, guinea pigs, and dogs was attempted. In order to establish the part that nutrition plays in the defective-enamel formation, the experimental animals were placed upon deficient diets of various types. Special interest was centered in planning diets in which the tooth-forming elements, calcium and phosphorus were present in deficient amounts, or in disproportion to each other; also in which were lacking the calcifying vitamin-D, the regulator of the metabolism of calcium and phosphorus. Whereas

pronounced abnormalities of formation and calcification of the teeth were obtained, as evidenced by outward appearance and substantiated by chemical analyses, no defect entirely similar to the characteristic mottled enamel of humans was obtained. Investigation of the possible relation of poor nutrition of the tooth to the faulty food selection of the children of St. David was carried on at the same time by Miss Ruth Leverton, graduate assistant. She lived in the community for three weeks, from October 3 to 24, 1930, and accurately obtained composites of the week's dietary of nineteen St. David children ranging in age from 3 to 15. Subsequent laboratory analyses of these composites have shown that the dietaries were not sufficiently inadequate, in either calcium or phosphorus, to be the sole cause of such serious interference in the development of the teeth as occurs in mottling of the enamel.

Hoping to prevent the mottling of the teeth of St. David children, and working on the possibility that poor nutrition of the teeth owing to lack of a sufficient concentration of the tooth-forming elements, calcium, phosphorus and vitamin D might be a contributing factor, supplemental feeding of thirty-five children has been carried on since October, 1930, the results of which will be reported later. In the light of the experiments in which we have investigated the relation of diet to the occurrence of mottled enamel, we can not agree with Pierle, who claims that it is possible to produce typical mottling simply "by lowering the calcium content of the diet below that needed for the growing animal."

In order to test the circumstantial evidence for conviction of the water-supply as the causative factor of mottled enamel, another series of experiments was planned in which water obtained from St. David was used as drinking water for a large number of animals whose littermates received distilled water. The same types of normal and abnormal diets were used as in the previous experiments. Inspection of the teeth with a hand lens was made every other day during the experimental periods of 3, 5, 7, 9 and 12 weeks, and the incisors prepared for chemical analysis and histological sectioning. No destructive effect of the St. David water on the teeth was noticed when the diet was adequate in all respects. When however the diet was deficient enough in itself to produce observable changes in the teeth, all the animals receiv-

ing St. David drinking-water gave evidence of this interference with normal development at an *earlier age*. This evidence strongly favored the idea that St. David water contained something whose destructive action was more pronounced when the tooth was poorly nourished.

Last fall, realizing the possible influence of the greater growth rate of the incisors of rats as compared with those of children, we concentrated the material in the St. David water by evaporation to one-tenth of its original volume, and gave this concentrate to rats to drink. In some cases, the water residue was incorporated in the ration. The results were strikingly positive. Even though the diet was adequate in all respects for the normal development of rat teeth (Sherman diet B), in a week's time a difference was noted in the appearance of the teeth of the litter mates. The enamel of the rats receiving residue from St. David water quickly lost its translucency and normal yellow-pigment, becoming whiter and more opaque than that of the littermates receiving the same basal ration but with distilled water. In a month's time, gross defects in the teeth of the animals that received the concentrated water from St. David were observed, the enamel then being not only strikingly dull, chalky white in appearance, but also pitted and corroded. Sections of the enamel chipped off. That the characteristics of the enamel dystrophy produced are similar if not identical with the mottling seen in humans is evident from inspection of the accompanying illustrations (*figs. 2, 3,* and *5*). It seems to the writers that the chalky white, corroded condition of the enamel of the animals receiving St. David water is proof in itself for conviction of the water supply of St. David as the prime etiological factor in mottled animal.

In progress at the same time was another series of experiments planned to throw light on the problem from another angle. Chemical compounds, suspected as capable of interfering with enamel calcification for one reason or another, were added either to the water or food of our experimental animals. Group separation of the metallic ions present in water from St. David had shown the presence of small amounts of calcium, magnesium, sodium and potassium, and traces of iron and aluminum, none of which have been found to affect tooth development adversely. Manganese, reputed to be a constituent of the "brown stain," was not present in any water from St. David, nor did

added manganese produce any observable effect upon rat teeth. However, results of feeding sodium fluoride in this laboratory in concentrations of 0.025, 0.05 and 0.1 per cent of the diet have been enlightening, for within a week's time the incisors of the animals began to lose their luster, assuming a dull, white, opaque appearance. Within a month, with the aid of the hand lens, a corroded, pitted condition of the enamel could be observed, and whole sections of the enamel had chipped off (*fig. 4*). All the characteristics of the enamel defect were strikingly similar to those produced by St. David-water residues. In 1925 McCollum and co-workers reported a disturbance in the structure of the teeth of rats produced by amounts of fluorine only slightly above those occurring in natural foods. McCollum stated that the incisors of rats given sodium fluoride were abnormal in color, the orange tint normally seen on their anterior surfaces being absent. He also observed that the teeth grew into abnormal positions owing to change in structure and hardness. From time to time other workers have also briefly mentioned the abnormal effect of fluorine on teeth, but in no case was the observed defect associated with the mottled teeth of human beings.

Qualitative analysis of St. David water for fluorine then followed, using the etching-of-glass test, and its presence revealed. Tucson city water did not respond to this test. Gautier has reported the fluorine content of water of different types in France, showing that most waters contain some fluorine, but that the fluorine content of waters is subject to wide variation, so called mineral-waters containing abnormal amounts. As his method for the quantitative measurement of fluorine demanded special apparatus and involved a long time for operation, the quantitative method of Reynolds, Ross, and Jacob,[2] developed for determining the percentage of fluorine in rock phosphates, was modified to suit our needs. The method consists briefly of converting the fluorine into silicon tetrafluoride by the addition of pure silica and 98 per cent sulphuric acid, volatilizing by heating to 300°C., absorption of the gas in water and titration of the resultant hydrofluosilicic acid, correction being made for other acid radicals.

The quantitative analyses for fluorine of waters from regions in which

[2] Reynolds, Ross and Jacob: *Journal of the Association of Agricultural Chemists*, 1928, xi, p. 225.

mottled enamel was endemic, and other Arizona sections in which mottled enamel was absent, confirmed the previous experimental evidence that mottled enamel was caused by the presence of fluorine in

FIG. 1. Typical cases of mottled enamel among school children in St. David, Ariz.

the drinking water of the endemic communities. Determination of the fluorine content of twenty Arizona waters has shown a wide variation. The artesian water-supply of eight different St. David families, all the members of which possess mottled enamel, showed a fluorine

FIG. 2

FIG. 3

FIG. 4

FIG. 2. Normal rat teeth; × 7. Note smoothness and translucency of enamel.

FIG. 3. Mottling produced in teeth of rats on an adequate ration, plus residues from St. David drinking-water; × 7. Note chalky whiteness, and corroded and pitted condition of enamel.

FIG. 4. Mottling produced in teeth of rats that received an adequate ration containing 0.05 per cent of sodium fluoride; × 7. Note characteristic enamel defects.

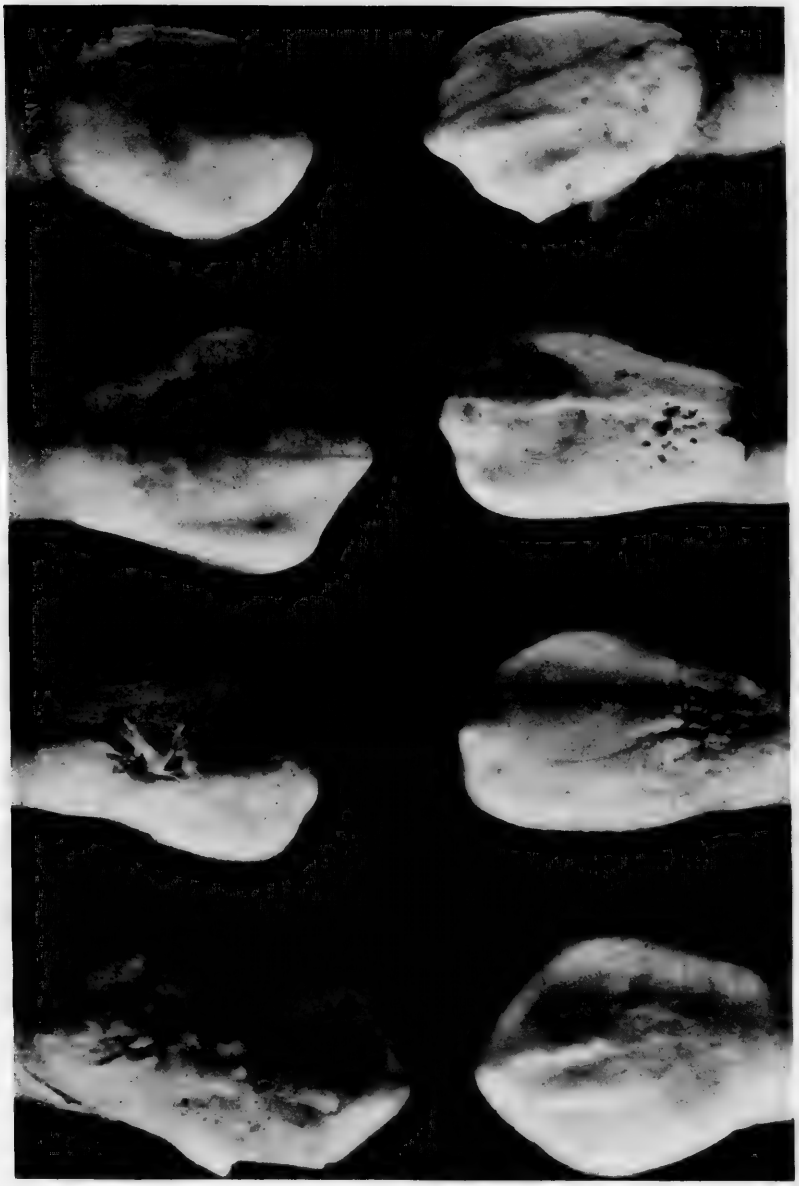

FIG. 5. Human teeth, showing moderate mottling; × 4. Taken from mouths of Pima Indians on government reservation at Sacaton, Ariz. Drinking water contained 3.9 mg. of fluorine per liter.

content varying from 4 to 7 mg. per liter. Waters from Tucson, Covered Wells, Sells, etc., which are non-endemic communities, were found to contain but small amounts if any (0 to 0.3 mg. per liter). Again, samples of water from other endemic communities—Sacaton, Willcox, and Florence—were found to contain abnormally high amounts of fluorine.

Another interesting case of the association of mottled enamel with fluorine in the water was observed in St. David. Analyses of the artesian well-water of a family living 7 miles south of St. David (considered to be a member of the community), showed a comparatively low content of fluorine—0.72 mg. per liter compared with 4 to 7 mg. per liter in the other wells. The three children of this family are the only children born and raised in the community who are free from mottled enamel. Their well is 775 feet deep as compared with an average depth of 350 feet for all other artesian wells in that locality.

The geologic relation of the water supply of different regions is being investigated. The nearby finding of fossil remains of prehistoric animals of the Cenozoic era (mastodons), the bones and tusks of which are unusually rich in calcium fluoride, suggests a possible source of contamination of the water in the St. David area. It is also interesting to note that the majority of the communities in Arizona in which mottled enamel is endemic lie along the Gila and San Pedro rivers. As the San Pedro River flows into the Gila River a common source of contamination is suggested. Again it is significant that Colorado Springs, another endemic community, draws its water supply from Pike's Peak, the granite of which contains cryolite (sodium aluminum fluoride) as an accessory mineral.

Analysis and histological sectioning of the bones and teeth of the animals receiving St. David water residues are in progress. Further study of the mode of action of fluorine and its effect on the metabolism of animals is being investigated, work being actively in progress on all these lines.

Summary and conclusions[3]

Mottled enamel is endemic in St. David, Arizona. Every child exposed to the environmental conditions of this community during the

[3] Not included in the paper as read at Pittsburgh; reprinted from *Technical Bulletin No. 32*. See footnote 1, p. 149.

years of growth of the enamel of the permanent teeth is certain to have mottled enamel. In a search for the cause of mottled enamel several theories of other workers have been tested and disproved. On the other hand the belief that the water supply is the source of the trouble has been proved by the production of a condition similar to, if not identical with, mottled enamel in experimental animals given St. David water to drink or given food in which the residue from St. David water had been incorporated.

The mottling of the enamel thus produced has been found to be identical with that resulting from the inclusion of sodium fluoride in the ration.

Quantitative analyses of the water of St. David and other Arizona communities in which mottled enamel is prevalent has revealed the presence of fluorine in abnormal amounts varying in St. David waters from 3.8 to 7.15 mg. per liter. On the other hand, waters from non-endemic communities contain only small amounts of fluorine if any (0 to 0.3 mg. in waters tested).

Thus definite proof has been advanced to show that mottled enamel, a defect of the enamel of human teeth, prevalent in many parts of the world, is caused by the destructive action of fluorine from the water supply of the afflicted communities.

THE PRODUCTION OF DENTAL CARIES IN RATS FED AN ADEQUATE DIET[1,2]

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Inasmuch as the subject of dental caries has recently been thoroughly reviewed by Bunting (1) and Hanke (2), it seems unnecessary to present another review at this time. Perhaps it is sufficient to state that at present the prevailing opinions about the cause of caries involve deficiencies of one or more dietary factors. The bacteriological origin has for the moment been relegated to the background. It is the purpose of this paper to describe some simple experiments indicating that caries may be produced on diets that are apparently entirely adequate with respect to the various factors deemed essential for normal dental development and maintenance. These experiments seem to show, therefore, that the caries-producing process is independent of the internal structure of the tooth, and probably involves acid fermentation as the responsible factor.

In 1929 there was begun a series of experiments with rats in which were fed diets similar to those used by Mellanby (3) in the production of hypoplastic teeth in puppies. The basal oatmeal-diet was modified by supplementing it with various dried vegetables, to see what effect these might have on the structure of the bones and teeth. A group receiving the stock ration (yellow corn 60, whole-milk powder 30, linseed meal 6, alfalfa meal 3, sodium chloride 1) was included as a normal control. At the end of the experimental period of sixteen weeks the rats were killed, and the bones and teeth examined. Con-

[1] This work is taken in part from the thesis submitted by P. A. Webber to the Graduate School of Michigan State College in 1930, in partial fulfillment of the requirements for the degree of Doctor of Philosophy. A preliminary report was published in *Science:* 1931, lxxiv, p. 77; July 17.

[2] Acknowledgment is made to the Department of Bacteriology, particularly for the council of Dr. E. D. Devereux, and the services of Mr. J. L. Etchells, to whom we are indebted for the bacteriological studies in connection with this work.

trary to expectations, decay of the teeth was found to have taken place only in the rats on the stock ration, in spite of the fact that the latter showed better growth and better skeletal development. An examination of other animals on the stock ration disclosed the fact that with very few exceptions the lower molars were involved in extensive decay. *Fig. 1* shows a few specimens taken from stock rats.

The persistent occurrence of caries in the stock rats indicated that no accidental combination of circumstances accounted for this condition, but pointed rather to a definite cause, reproduceable and producing definite effects. Inasmuch as the biggest difference between the stock ration and the experimental diets was the cereal constituent, it was decided to replace the cornmeal with oatmeal, using the stock ration formula. When this was done no caries developed. Obviously then the cornmeal played an important rôle in the production of caries. This belief was further strengthened by the fact that rats on various experimental diets containing cornmeal almost without exception showed signs of dental decay, whereas those on similar diets containing oatmeal showed no indications of caries. It was observed, moreover, that with diets containing cornmeal there was a tendency for particles of the corn to become lodged in the dental grooves, usually of the lower molars. This was followed by the development of small cavities, which encouraged more impactions of food and subsequently more extensive decay. Inasmuch as the tendency to impaction of the food appeared to be dependent on the size of the cornmeal particles, a series of feeding tests was carried out using cornmeal of varying degrees of fineness. In this series of tests the stock ration was simplified by omitting the linseed meal, so that the following dietary formula was used: cereal 66, whole-milk powder 30, alfalfa meal 3, sodium chloride 1.

The cornmeal, as received from a local milling concern, had approximately the following distribution of particles: On a 20-mesh screen 45 per cent; on a 40-mesh screen 30 per cent; on a 60-mesh screen 12 per cent; through a 60-mesh screen 13 per cent. In the preparation of the various fractions, this cornmeal was first put through a Wiley mill, using the coarse screen and then fractioned with large sieves. This extra grinding was found necessary in order to obtain large enough quantities of the finer fractions for feeding experiments. The specimens shown in *fig. 2* were taken from rats kept on these rations for eight

weeks. In these, as well as in all subsequent experiments, the rats were placed on the experimental diets at four weeks. It is apparent that there is a gradual decrease in the severity of the carious lesions as the cornmeal is more finely ground. Under the conditions of the experiment no impactions of food occurred with the meal that passed through a 60-mesh sieve, and consequently no decay of the teeth took place. No impactions of food were observed on the oatmeal diet, and again there was no evidence of caries. *The retention of food by the teeth, therefore, seems to be a determining factor in the production of caries.*

In order to broaden the scope of our studies it was next felt desirable to compare corn with rice and wheat of similar fineness. The grains were put through the coarse sieve of a Wiley mill. Two types of diets were employed, one intended to produce good skeletal and dental development; the other, inferior development of these tissues. The first diet was composed of the following: cereal 80, whole-milk powder 10, dried yeast 5, alfalfa meal 3, calcium carbonate 1, sodium chloride 1. In the second series the calcium carbonate was omitted, resulting in poorer growth and skeletal development. Ash determinations carried out on the fat-free mandibles gave average values of 65.3 per cent for the first series and 58.8 per cent for the second. There was no significant variation between the groups on the several grains, and for this reason the individual ash-data are not presented. Contrary to expectations the first group, in spite of its better growth and skeletal development, showed far greater severity of caries than the second, as may be seen in *fig. 3*. It is believed that these unexpected results are due simply to the fact that, in the second group, impactions of particles of grain did not occur as readily as in the first group, because the retarded growth of the rats affected the size of the teeth and therefore the size of the dental grooves. This in turn reduced the tendency for impaction of particles of grain, and resulted in less decay of the teeth. In contrast to the results with corn and rice, only a few very small cavities were observed in the rats receiving the ground wheat. Periodic examinations of the teeth of these rats showed little tendency for impactions of food, which is probably due to the fact that the wheat was a hard flinty variety. Experiments with soft wheat have yielded results that are more comparable with those obtained with corn and rice.

Inasmuch as certain dietary factors have been emphasized in connection with the development of sound teeth and the prevention of decay, the modified stock ration was supplemented with materials intended to supply an abundance of the various factors. The results of these tests are presented in *fig. 4*, the specimens again having been derived from rats started at 28 days and kept on the experimental diets for 8 weeks. The specimens show clearly that the addition of liberal amounts of vitamin A, D or C, or of calcium and phosphorus, did not appreciably retard the decay of the teeth. *This points to a lack of direct relationship between any of these factors and the caries-producing process.* In making this statement it is not intended to minimize in the least the general importance of certain vitamins and inorganic elements, for their place in the diet is well recognized. Since it is believed by some investigators that a change in internal structure, having its origin in some metabolic disturbance, is an important if not an essential factor in the susceptibility of teeth to decay, a few microphotographs are included, but this histological evidence does not appear to support the metabolic theory (*figs. 5, 6* and *7*).

Regarding the bacterial side of the problem, we have little to report beyond the fact that in every case examined acidogenic bacteria were found. These have not yet been identified, but there can be no doubt as to their acid-forming tendencies. In addition, proteolytic bacteria have been isolated from the carious lesions of a few rats. The presence of this type of organism completes the mechanism for the complete disintegration of dental tissue. That this mechanism is capable of causing the destruction not only of the dental but of the bone tissue as well is strikingly shown in specimen 8 in *fig. 1*. In this case, as with many others, there was an abundance of impacted food, which when removed revealed a marked erosion of the bone tissue. That these cavities did not arise from a metabolic disturbance is obvious, particularly since the diet in question has given very satisfactory results for growth and reproduction in our rat colony for a period of over three years.

The experiments described in this paper present a simple picture of dental caries as it probably occurs in the majority of cases. Two conditions must be fulfilled: the retention by the teeth of carbohydrate-containing foods, and the presence and action of acidogenic and prob-

ably of proteolytic bacteria. When these conditions are fulfilled, destruction of the teeth takes place irrespective of the inner structure of the teeth; although it is obvious that the denser the structure, the slower will be the dissolution. It is a common observation of dentists that cavities are not confined to soft teeth, nor do soft teeth necessarily always show evidence of decay.

Regarding the first of the *conditions* mentioned, two *factors* are primarily involved. Of these the nature and consistency of the food is perhaps the more important. While we have been dealing in our studies with retention of food due to impaction of particles of a particular size, probably another type of retention is much more common in humans; namely, retention due to plasticity and adhesiveness. Certain carbohydrate-containing foods when masticated have a tendency to form a sticky plastic mass, which is readily forced into the dental grooves and interstices, from which it may be removed only with difficulty and often incompletely, in spite of the fact that an effort may be made to clean the teeth. Coöperating with this *factor* is the second *factor;* namely, the shape, and to a lesser extent, the location of the teeth. This point is clearly demonstrated in the various illustrations that, without exception, show decay of either the front or central mandibular molars. In our studies thus far, decay of the uppers has been very sporadic. The partiality in the selection of certain teeth for decay is also characteristic in the case of children, for it is not uncommon to find one or more of the molars involved in extensive decay, whereas the other teeth may be in perfect condition. It is true, of course, that poor dental development may be caused by deficiencies in the diet and may result in structural imperfections, such as pits and fissures, which, because of their nature and location, are very likely to retain food and lead to the decay of the teeth. The practice of filling such pits and fissures, even before there are any evidences of decay, as is advocated by Hyatt (4) and others, is believed, from the results of these experiments, to be fully justified, and worthy of general adoption by the dental profession.

The second of the *conditions* necessary for the production of dental caries is the presence and action of acidogenic bacteria. Such bacteria have been found in every carious lesion thus far examined. This is in full accord with the extensive observations made by Bunting (5) and

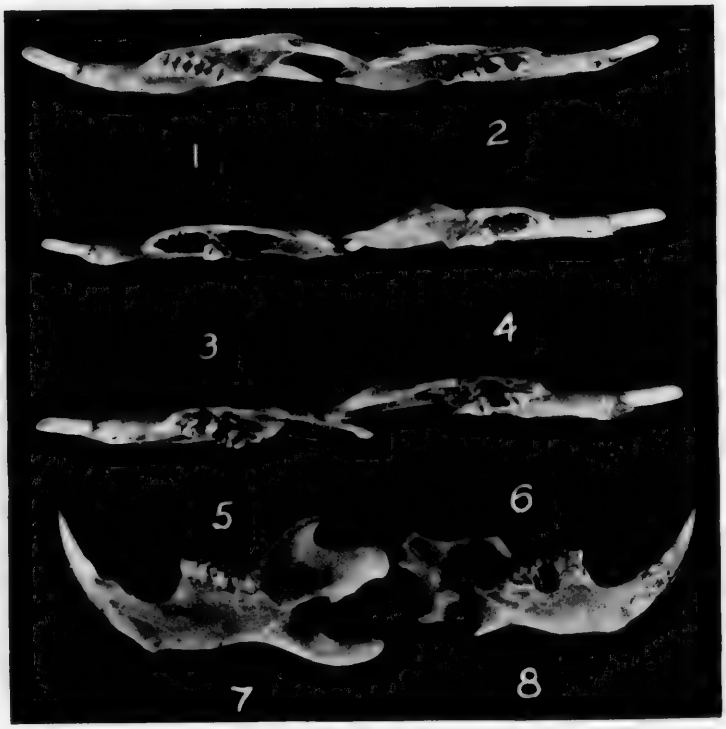

FIG. 1. MANDIBLES DERIVED FROM RATS OF BREEDING COLONY RECEIVING STOCK RATION

Specimens 1 and 7 are normal; all others show caries in different degrees of severity

FIG. 2. MANDIBLES FROM RATS RECEIVING CORNMEAL IN DIFFERENT DEGREES OF FINENESS

1.—Coarse cornmeal. *2.*—Cornmeal retained on 20-mesh sieve. *3.*—Cornmeal retained on 40-mesh sieve. *4.*—Cornmeal retained on 60-mesh sieve. *5.*—Cornmeal passing through 60-mesh sieve. *6.*—Ground oatmeal.

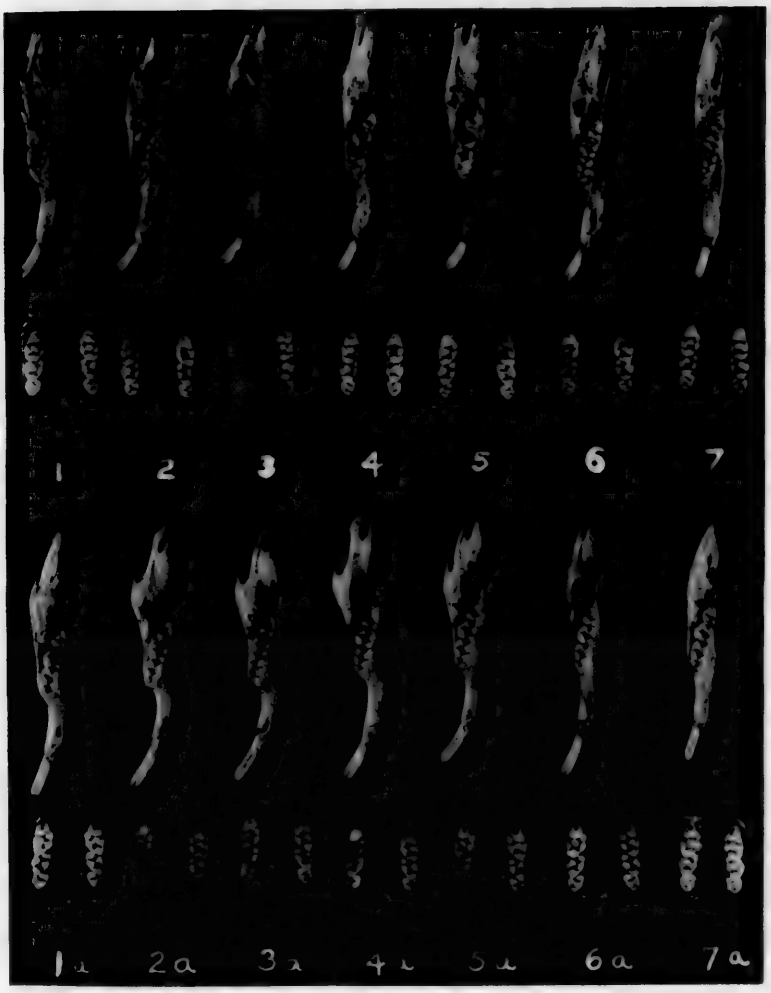

FIG. 3. COMPARISON OF CORN WITH RICE AND HARD WHEAT IN PRODUCTION OF DENTAL CARIES IN RATS

Note cavities in upper molars of *2*, *4* and *5*.

Diet *with* calcium carbonate: (*1*) oatmeal; (*2–3*) corn; (*4–5*) rice; (*6–7*) wheat.

Diet *without* calcium carbonate: (*1a*) oatmeal; (*2a–3a*) corn; (*4a–5a*) rice; (*6a–7a*) wheat.

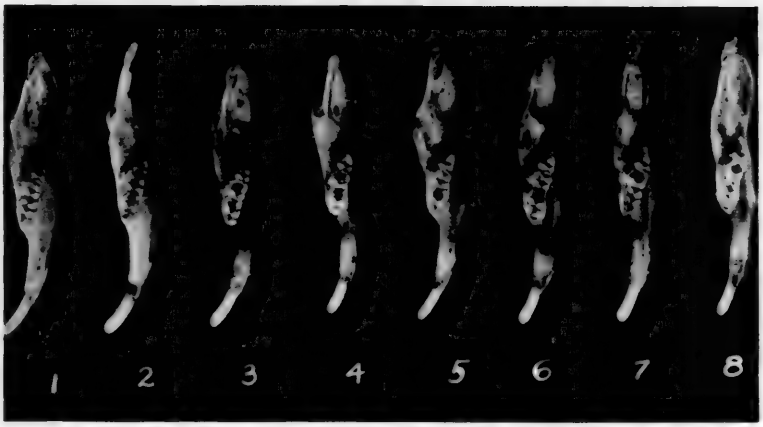

FIG. 4. MANDIBLES FROM RATS RECEIVING STOCK RATIONS, WITH SUPPLEMENTS OF VARIOUS DIETARY FACTORS

1.—Oatmeal ration. *2.*—Coarse-cornmeal ration. *3.*—Coarse-cornmeal ration, plus 1 per cent *cod-liver oil*. *4.*—Coarse-cornmeal ration, plus 1 per cent *calcium carbonate*. *5.*—Coarse-cornmeal ration, plus 1 per cent *tricalcium phosphate*. *6.*—Coarse-cornmeal ration, plus 1 cc. *orange juice daily*. *7.*—Coarse-cornmeal ration, plus 15–20 grams fresh *cabbage daily*. *8.*—Coarse-cornmeal ration, plus 15–20 grams fresh *carrots* daily.

FIG. 5. PHOTOMICROGRAPH OF LONGITUDINAL SECTION OF CARIOUS MANDIBULAR MOLARS; ONE IS IMPACTED WITH FOOD

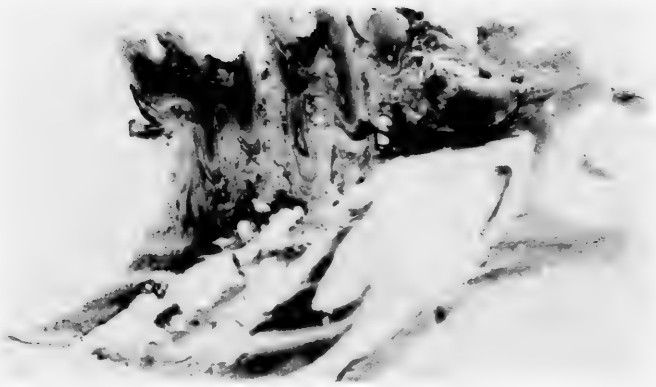

FIG. 6. PHOTOMICROGRAPH OF SECTION OF MANDIBLE PREPARED BY FORMIC-ACID-DECALCIFICATION, CELLOIDIN-IMBEDDING METHOD; PART OF FIRST MOLAR DISINTEGRATED BY CARIES

FIG. 7. PHOTOMICROGRAPH FROM GROUND SECTION, AFTER IMBEDDING IN GEORGIA ROSIN

Note that, by this method, enamel is preserved. Dark stained areas in dentin show softening effect of caries.

his co-workers. The failure of Howe (6) and others to produce caries, by inoculating teeth with certain acidogenic organisms, does not constitute conclusive proof that these organisms have nothing to do with the decay of teeth. These negative results may have been due to failure to cause retention of food by the teeth, and therefore to provide favorable conditions for the existence and activity of the organisms in question. There is also the possibility that not all acidogenic bacteria thrive under the conditions existing in the mouth. Whatever the case may be, the bacteriological phase of the problem is worthy of further study.

The results of these experiments indicate that it would be profitable to investigate foods from the standpoint of their retention by the teeth in human subjects. Inasmuch as decay of teeth does not appear to be due primarily to a deficiency of a particular dietary factor or to a combination of factors, it seems highly probable that a plan for the prevention of caries might be evolved that would be more easily attainable by the masses than the plans suggested by Howe (7) and Hanke (8). More practical are the dietaries used by Bunting (9) in controlling dental caries among the children in several public institutions. It is believed that such an investigation would be another approach to the solution of the problem of dental caries.

REFERENCES TO LITERATURE

(1) Bunting, R. W. A review of recent researches on dental caries. *Jour. Amer. Dental Assoc.*, 18: 785–806 (May), 1931.

(2) Hanke, M. T. The rôle of diet in the cause, prevention and cure of dental diseases. *Jour. Nutr.*, 3: 433–451 (Jan.), 1931.

(3) Mellanby, Mrs. May. Diet and the teeth. *Brit. Jour. Dent. Science*, 64: 70–81, 1921.

(4) Hyatt, Thaddeus P. Recent investigations in prophylactic odontotomy by the Hyatt Study Club. *Jour. Amer. Dent. Assoc.*, 17: 1568–1576 (Aug.), 1930.

(5) Bunting, R. W., and Palmerlee, Faith. Rôle of B. acidophilus in dental caries. *Jour. Amer. Dent. Assoc.*, 12: 381 (April), 1925.

Bunting, R. W., Nickerson, Gail, and Hard, Dorothy G. Further studies on the relation of B. acidophilus to dental caries. *Dent. Cosmos*, 68: 931 (Oct.), 1926.

Bunting, R. W., Nickerson, Gail, Hard, Dorothy G., and Crowley, Mary. Further studies of the relation of B. acidophilus to dental caries; II. *Ibid.*, 70: 1 (Jan.), 1928.

Bunting, R. W., Crowley, Mary, Hard, Dorothy G., and Keller, Margaret. Further studies of the relation of B. acidophilus to dental caries; III. *Ibid.*, 70: 1002 (Oct.), 1928.

(6) HOWE, P. R., AND HATCH, RUTH E. Study of micro-organisms of dental caries. *Dent. Cosmos*, 59: 96, 973 (Oct.), 1917.

(7) HOWE, P. R. Practical nutritional suggestions for dentists. *Jour. Amer. Dent. Assoc.*, 17: 2140–2143 (Nov.), 1930.

(8) HANKE, M. T. Relation of diet to general health and particularly to inflammation of oral tissues and dental caries. *Jour. Amer. Dent. Assoc.*, 17: 957–967 (June), 1930.

(9) BUNTING, R. W., JAY, PHILIP, AND HARD, DOROTHY G. Report of the successful control of dental caries in three public institutions. *Jour. Amer. Dent. Assoc.*, 18: 672–678 (Apr.), 1931.

ADDENDUM[3]

Was the production of caries in our rats due to a deficiency of phosphorus in the diet?

In recent comment by Klein and McCollum[4] exception was taken to the explanation that caries in our work[5] was caused by the retention of particles of cornmeal by the teeth, with subsequent bacterial action; and that the fineness of the meal was an important factor in the production of caries. Klein and McCollum suggest that the caries in our experiments was due rather to a deficiency of phosphorus in the diet. While it is true that the cornmeal passing through a 60-mesh screen was richer in phosphorus (owing to removal of some of the bran), and thus effected a slight increase in the phosphorus content of the ration as indicated by the analyses of Klein and McCollum, we believe that this difference in the intake of phosphorus had nothing whatever to do with the development of caries. For one thing, it is extremely unlikely that diets such as ours, that have given very satisfactory results for growth, reproduction, and lactation, could be deficient in so essential an element as phosphorus. Moreover, diets containing oatmeal, and having appreciably less phosphorus than the one considered by Klein and McCollum to be deficient in this element, have been fed without producing caries at all. It would appear logical to conclude, therefore, that the development of caries may, within certain limits at least, be independent of the phosphorus content of the diet.

[3] The manuscript of the paper to which this is an addendum was received for publication on December 16, 1931.—[*Ed.*]

[4] Klein and McCollum: *Science*, 74: 662; December 25, 1931.

[5] Hoppert, Webber, and Canniff: *Science*, 74: 77, July 17, 1931.

In *Table 1* are recorded the results obtained with another type of diet that has been used in our studies on dental caries. The phosphorus and calcium values have been calculated from those used by Klein and McCollum. The data for the femurs and humeri have been included, because these values express accurately the ability of the diets to support calcification of the bones and teeth. Concerning the

TABLE 1

Data showing lack of relationship between phosphorus content of diet and incidence of caries

DIET	PARTS	P	Ca	Ca + P RATIO	CARIES	AVERAGE OF FEMURS AND HUMERI
		gram	*gram*		*per cent*	*per cent*
I. Cornmeal	69	0.2001	0.0096			
Wheat gluten	20	0.0400	0.0156	0.263	90–100	43.5
Whole-milk powder	5	0.0420	0.0490			
Crisco	5	—	—			
NaCl	1	—	—			
	100	0.2821	0.0742			
Same diet, with 1 per cent $CaCO_3$		0.2821	0.4742	1.68	90–100	50.4
II. Oatmeal	69	0.2994	0.0762			
Wheat gluten	20	0.0400	0.0156			
Whole-milk powder	5	0.0420	0.0490	0.41	0	45.5
Crisco	5	—	—			
NaCl	1	—	—			
	100	0.3436	0.1408			
Same diet, with 1 per cent $CaCO_3$		0.3436	0.5408	1.57	0	51.9
III. Stock ration* (coarse cornmeal)		0.4802	0.3424	0.7	90–100	56.2

* Values given by Klein and McCollum.

calcium-phosphorus ratios, it is obvious that these bear little relation either to the incidence of caries observed in the rats, or to the ash content of the bones. Moreover, there is no correlation whatever between the ash content of the bones and the incidence of caries. The development of caries in the rats was just as frequent on the cornmeal diet that produced bones yielding 56.2 per cent ash as on the cornmeal diet that gave bones yielding only 43.5 per cent ash. In

contrast to these results, caries was not observed in any of the rats receiving the oatmeal diets, whether the ash content of the bones was high or low.

These results permit of only one conclusion, and that is that variation in the phosphorus content of the diets in our experiments had no connection with the outcome. It has always appeared rather strange that whereas a deficiency in the diet, be it an inorganic element or a vitamin, caused *general* metabolic disturbances, the same deficiency should, in the case of caries, affect *one tooth* and leave the adjacent one untouched. It would be just as reasonable to expect one femur of a rat, on a deficient diet, to have an ash content of 40 per cent, and the other femur to have one of 55 per cent. The localization in the decay of teeth is most reasonably explained on the basis of action by certain factors exterior to the teeth. Until a more plausible explanation is forthcoming, we shall adhere to our original conclusions concerning the cause of the caries in our experiments, which are repeated in the foregoing paper.

THE MANAGEMENT OF THE MALPOSED INFERIOR THIRD MOLAR

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I. INTRODUCTION

The problem of the inferior third molar is very complex. It is of interest to the physician as well as to the dentist. It enters the field of the orthodontist, the otologist and the neurologist. It can be discussed from many angles. The etiology, classification, position of the tooth, symptomatology, and different pathological conditions associated with it, furnish material for extensive study. The advantages and disadvantages of various operations for the removal of a malposed tooth are of particular interest to the oral surgeon, and of even greater concern to the patient. A frank discussion of this subject should, therefore, be of interest especially to the general practitioner, on whose judgment the patient has to rely when referred for the operation.

The two most important factors governing the success or failure of the operation are the effect of the anesthetic on the smooth progress of the operation, and the potential danger of accidents from the technical procedure. In a study of fracture of the mandible, caused by

removal of malposed third molars, I have found that in most cases the operation was performed with nitrous oxide and oxygen anesthesia, which, as will be seen later, is perhaps the most unsatisfactory of the general anesthetics for an operation on a difficult third molar. In regard to position, most of the cases belonged to Class Ib, some to Classes IVa, and IVb, and one to Class IIIa. In three cases the second molar—in two, the second and third molars—were missing. The main cause of the fractures seems to have been the application of excessive force by means of powerful exolevers; or the use of force applied in the wrong direction, or before completing the preparatory steps. Excessive bone-resection is evident in the x-rays of three cases. Whether this was caused by the use of ossisectors, or due to trauma from the application of exolevers, could not be ascertained. Another operative complication arises from the injudicious use of exolevers between the second and third molars. In many cases the alveolar crest, and often half the alveolar septum, is destroyed; and after complete healing, the superior part of the distal surface of the second-molar root remains exposed. In one case that came to my attention, the second molar had been luxated, the pulp had become necrotic, and the tooth was infected; evidence of periapical infection was seen in an x-ray taken eight months later, and extensive infection was visible after seventeen months. These cases, some of which are illustrated in *figs. 1* to *5*, teach us that excessive force should be avoided. With the method to be described, it is possible to remove malposed third molars without the use of excessive force, or the resection of inordinate amounts of bone. To accomplish this result, proper thought must be given to the steps preceding the luxation of the tooth. While such an operation may require a little more time and more careful technique, and an anesthetic that does not interfere with uninterrupted vision and accessibility of the field, it eliminates almost entirely the danger of accidents. Having used this method for more than fifteen years, I feel that it has stood the test of time.

II. DIAGNOSIS AND CLASSIFICATION

Two problems are generally involved in an examination for a malposed tooth. It may be necessary to determine whether the tooth is, or may become, the cause of certain objective or subjective symptoms.

FIG. 1. Simple mandibular fracture, caused by instrumentation. Tooth, Class Ib, not removed by operator after fracture.

FIG. 2. Simple fracture of mandible, with forward displacement of ramus, caused during removal of Class IVb. From appearance in x-ray, force was applied by operator before sufficient bone had been resected.

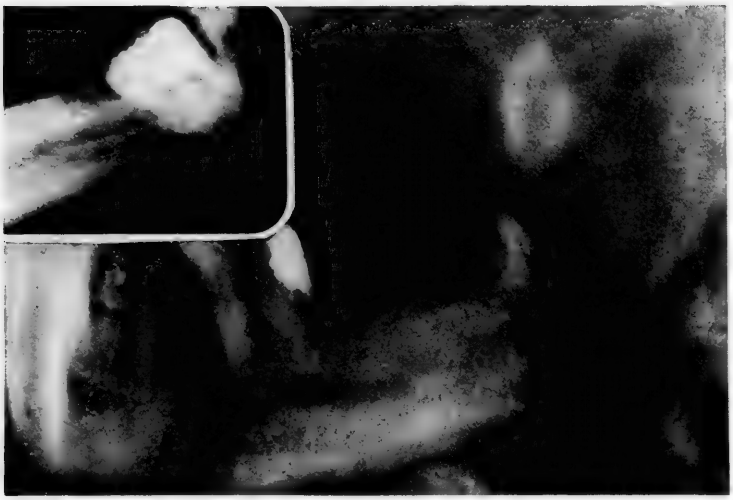


FIG. 3. Comminuted fracture in case of edentulous posterior part of mandible. X-ray was taken several weeks after operation; much swelling existed. Patient stated operator treated condition for severe postoperative complications, but did not diagnose or reduce fracture. Tooth, Class IIIa; see insert.

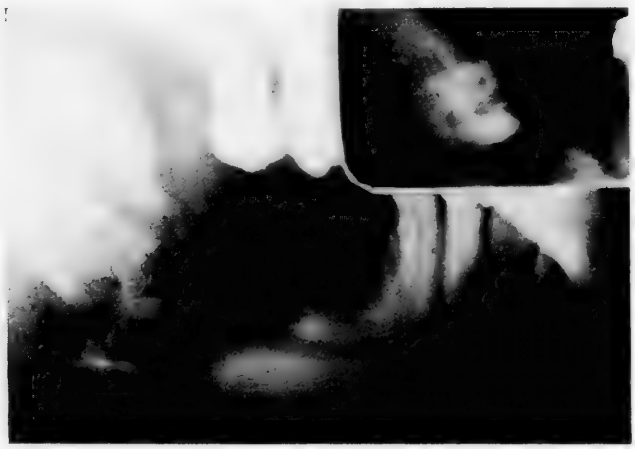


FIG. 4. Comminuted fracture of mandible caused by injudicious instrumentation. Posterior part of mandible edentulous. Tooth, Class IVa; see insert.

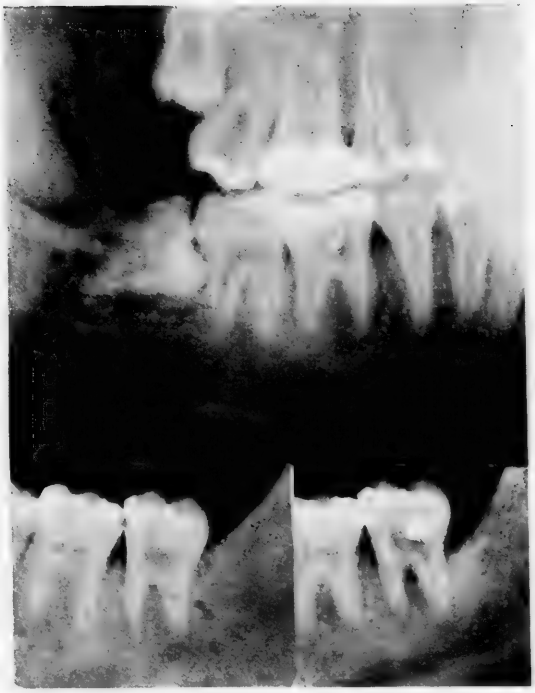
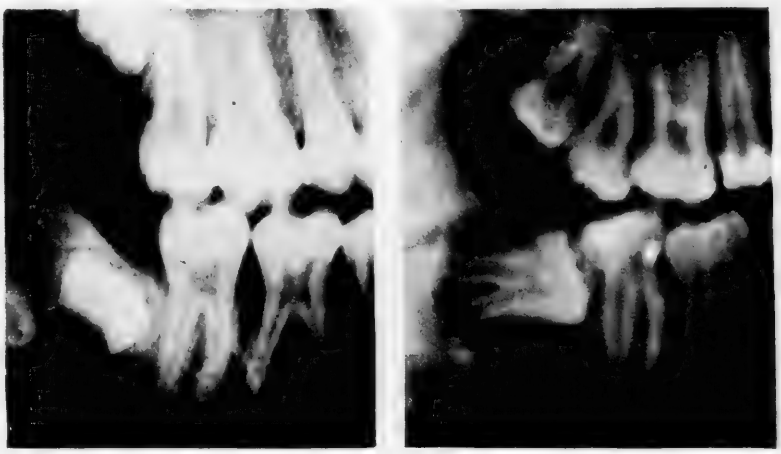


FIG. 5. Extraoral x-ray: Class IVa. Operator removed tooth and by accident luxated second molar; reason shown in *fig. 9*. Left lower intraoral film: result eight months later. Right lower film: periapical and apical changes after seventeen months.



A B

FIG. 6. *A*.—Partly formed third molar in mesio-oblique position (patient 13 years old); apparently room enough for normal development and eruption of tooth. *B*.—Same tooth at 20; horizontal position. (Courtesy of Dr. Fred Blumenthal.)

The information necessary for classification and selection of the proper operative technique must be obtained.

Roentgen examination. In many cases the roentgen examination is the only method by which the existence of malposed teeth can be determined. Even when they are partly erupted and, therefore, visible, roentgen examination is indispensable. It is the basis for classification; the means of recognizing such complications as cysts, otitis, or odontomata; and discloses the relations of the tooth to neighboring structures, such as the ramus, mandibular canal, and tissues around the second molar. The picture should show the entire outline of the tooth. This can generally be obtained with the ordinary dental film, if placed sufficiently far back in the mouth when the exposure is made. Where there is swelling or trismus, or the tooth is in an unusual position, extra-oral pictures give better results. The angulation of the tube should be such that there will be no overlapping, in the picture, of the second and third molars. Frequently patients, who have been referred to the oral surgeon, bring with them x-rays taken by general practitioners and showing only a part of the third molar. Such a picture, while sufficient to disclose the presence of the unerupted tooth, does not give the information the operator needs. It is my practice to take a new x-ray as part of the procedure in such cases, without special explanation to the patient or separate charge.

Objective symptoms. Objective symptoms are most frequent in cases where the tooth tries to erupt, or has pierced the gingiva. Sometimes the opening is barely visible; but just as soon as the surface is broken, infection enters. The tooth, as well as the surrounding tissue, may become involved, and caries, pulp infection, periapical infection, and gingivitis may occur. The latter may be aggravated by trauma when the inflamed gingiva over the tooth comes in contact with the opposing tooth in the upper jaw. If a perforation has been made, the tissue between the crown of the tooth and the encapsulating bone, which is the remnant of the tooth follicle, becomes infected. This "pericoronal" infection may involve only the gingival flap over the occlusal surface, but very frequently a large amount of infected granulation tissue is found between the distal surface of the crown and the ramus, or in the wedge-shaped space under the mesial surface of a mesially inclined tooth. On the other hand the radiolucent space,

normally occupied by the remnant of the enamel organ and dental follicle, when seen in an x-ray should not be mistaken for evidence of infection. This space varies in size, being larger in young patients and gradually becoming smaller. Generally, pericoronal infection is of the chronic or sub-acute type. A little pus can be pressed out at all times, but the patient seldom suffers more than a slight and intermittant discomfort. Acute pericoronal abscess is nearly always associated with swelling of the face in the submaxillary region, and muscular trismus, the jaw being locked. Pharyngeal and peritonsilar abscesses may result. If ulceration of the gingival perforation is noticed, an examination for Vincent's infection should be made.

Subjective symptoms. The patient may complain of very indefinite symptoms caused by nerve reflexes. These are produced by the eruptive pressure against an obstruction, such as the second molar or the tissue between the two teeth, the bone and the peridental membrane, the latter being richly innervated. The force is often so great that pressure absorption, even to involvement of the pulp, may occur on the side of the second molar. In other cases the developing roots may also produce pressure against the inferior alveolar nerve. This eruptive pressure, periodical in character, occurs more frequently in young individuals at the time when the tooth normally would erupt. It may produce a number of conditions that are not always easily recognized. A disturbance of the occlusion, and a consequent crowding in the incisor region, may be noted. The excellent work of an orthodontist may be undone. Neuralgic pain is a common symptom, and may be felt in the region of any of the branches of the fifth nerve. Otalgia dentalis is not uncommon, an anastomosis existing between the third division of the fifth nerve and the tympanic plexus. The patient may complain of an indefinable feeling of pressure, which frequently interferes with studying or other work, and may cause insomnia, extreme nervousness, and even mental disturbances.

Condition of second molar. The question whether extraction of the second molars instead of the third would give more satisfactory final results occurs in only very rare instances. Careful consideration and good judgment are involved. It is never advisable to extract second molars to avoid the more difficult operation. If, however, the second molars are badly carious, with pulp involvement, or if they are root-

filled teeth, with or without periapical infection, it is often advisable to remove them instead of the third molars. However, it must be remembered that much depends on the position and size of the third molars, and on the age of the patient. In order to preserve the symmetry of the arches, the treatment must be applied on both sides. But I should never sacrifice the second molars unless certain that the third molars would come into satisfactory position.

Classification. Malposed inferior third molars can be classified as to whether they are unerupted or partly erupted. They may be distinguished as imbedded or impacted, as Ottolengui (10) pointed out. But in the surgeon's view, the most important information is gained from a classification which takes into account: (*a*) The depth of the tooth; that is, the distance under the occlusal plane. "Partly" erupted, or "unerupted," may indicate this condition, but "high position" or "low position" is better. (*b*) The position of the tooth as viewed in an approximately sagittal plane. (*c*) The formation and curvature of roots. The position of the tooth is not necessarily permanent during the developmental stage. Blumenthal (2) has cited a case where a mesio-oblique tooth, at the age of 18, changed into a horizontal position two years later. Another similar case of his is shown in *fig. 6*. I have observed similar cases (14) and believe this change is the rule rather than the exception. As the patient gets older, there may be decrease in the size of the space occupied by the peridental membrane around the roots of the tooth, and also of the space occupied by the remnant of the enamel organ and dental follicle around the crown of the tooth. It is evident that a large space between the tooth and the encapsulating bone favors the operator. Therefore it is easier to remove malposed teeth at an early age. I do not agree, however, with those who advise operation only when the crown of the tooth has been formed (12 to 15 years). It is not easy to remove such crowns; they are generally deeply placed, and give a ball and socket action when an elevator is applied. Also, it must be remembered that, as Dewey (2) has pointed out in discussing Blumenthal's paper, third molars which appear impacted at an early age may assume their proper position in the arch at the time of eruption. The most favorable time in the surgeon's view for the removal of a malposed tooth is when the roots are about two-thirds to three-fourths

formed. At this time the patient has also reached an age which makes the operation easier.

I arrange malposed, inferior, third molars into five classes according to position, and into three subclasses according to curvature of the roots: (I) Vertical position. (II) Disto-oblique position. (III) Mesio-oblique position. (IV) Horizontal position. (V) Transverse position. —(a) roots straight; (b) roots curved distally; (c) roots curved mesially. An unerupted, inferior, third-molar class IIIb would therefore be in mesio-oblique, low position, with roots curved distally. See *fig. 7.*

III. ANESTHESIA

With the method for removing malposed third molars to be described later, the kind of anesthesia to be used becomes a matter of personal choice, unless the patient has some physical ailment, when a consultation with the patient's physician is desirable. The general practitioner who refers the patient can often make valuable suggestions about the management of the case, but he should avoid giving the patient a wrong impression. Cooke, in a paper on the "Relation of the exodontist to general dentistry" (3), makes the following statement: "The general dentist is too apt to pass the responsibility to the exodontist by reassuring his patient as to the simplicity of the operation, which both he and the exodontist may realize to be far from simple." It is true that such statements, which are always made with the best intentions, sometimes lead to unlooked for grievances, especially if the after-care interferes with fixed plans the patient might have made for the immediate future. Many cases are extremely simple and of course others are very difficult; the patient should be told the difference. This is not often done because most patients who have had previous experience remember only two things· that they had a "wisdom" tooth removed, and that the healing was either uneventful or marked with complications. It is of mutual advantage to see the patient for consultation before the appointment for the operation is arranged. This gives the oral surgeon a chance to make a careful examination of the case, explain the nature of the operation and after-care, study the mental attitude of the patient, and decide what anesthetic should be used.

The operator's requirements of the anesthetic. The degree of success of the anesthesia has a direct bearing on the efficiency of the operation. The following are my requirements of the anesthesia for operations on difficult malposed, inferior, third molars: (*a*) The anesthesia must be safe, involving the least possible risk. (*b*) The anesthesia must be complete and lasting, so that the operation can be finished without undue haste, no matter what difficulties are encountered during the operation. (*c*) The anesthesia must be continuous, so that the operation can be performed without interruption. (*d*) It must not interfere at any time with uninterrupted vision and accessibility to the field of operation. (*e*) It must afford control of bleeding, and exclusion of saliva or vomitus, which would cause contamination of the wound.

Choice of anesthesia. So long as the chosen anesthetic does not violate the above requirements, the patient's preference should be the first consideration. Many patients are biased by stories told by friends, and should be given the facts about the advantages and disadvantages of the different methods. Of course, some persons have a marked antipathy to instrumentation and operation, and even the sight of blood makes them faint. These should have the privilege of choosing a general anesthetic. A great many others abhor the idea of losing consciousness, dislike hospitals, and suffer extremely from nausea after general anesthesia. Such conditions present strong contraindications for general anesthesia and indicate the use of local. Nervousness is not in itself a contraindication of local anesthesia. As a matter of fact, I prefer local anesthesia to nitrous oxide and oxygen for this class of patients. It is perhaps more difficult to get their confidence and to have complete mental control over them, but when this is attained the operation can proceed without interruption. Under nitrous oxide and oxygen they give trouble, because they are nearly always shallow breathers, or promptly start to vomit food, which, undigested for hours on account of nervous apprehension, has been retained in the stomach. The consultant who refers the patient may be able to give advice on the subject of choice of the anesthetic, but it should be understood that the final decision rests with the man who has to perform the operation. I have had patients come to me with the statement that their dentist referred them to me because the operation could not be performed with a local anesthetic, and that he

does not give "gas" in his office. If you are of the opinion that the case should not be handled with "gas," in the office, you are involved in a difficult situation.

A. Local anesthesia

In order to use local anesthesia successfully, confidence and experience are necessary attributes of the operator, especially with the more difficult type of patient. The method is not easily adaptable to the crowded type of practice, in which the operator is unwilling to allow the necessary time for the injection to take full effect. Otherwise it is the ideal type of anesthesia for office operations.

Indication. All types of malposed third molars can be removed by this method. In very difficult cases it is advisable to limit the operation, at one sitting, to the removal of one superior and one inferior third molar on one side. Poor-risk cases, if difficult, should be hospitalized, even if local anesthesia is used. *Contraindications.* Local anesthesia is contraindicated in patients who object to being conscious during an operation, and in cases of extensive trismus and acute infection of the tissues surrounding the tooth.

Advantages. It gives the operator opportunity for careful, unhurried technique. It fulfills the above five requirements, and can be used in poor-risk cases for which general anesthesia is contraindicated. This method has also an economical factor to recommend it, which is important with a great many patients. Nitrous oxide and oxygen, if administered for any length of time, are expensive; and if an anesthetist is used, his fee may be a considerable item, not to speak of hospital expenses. Also, the time factor must be considered. With local anesthesia most patients can follow their regular occupations the day after the operation. *Disadvantages.* Mental control sometimes causes difficulties, especially in highly nervous individuals. They must be handled gently but with firmness, and never be allowed to feel any uncertainty on the part of the operator either as to the success of the injection or the outcome of the operation. Many patients have a recurrence of fear every time a new instrument is applied, while others are worried lest the anesthesia will wear off before the operation is completed. To the man who has become used to the routine, it is often impossible to believe that patients may fret because

they think the strange feeling in the face may be visible or permanent. It is good psychology to suspect and correct such errors before they are mentioned by the patient. The fact that errors in the technique of injection introduce a factor of failure is also a consideration. As mastery comes with experience, this factor, therefore, will be a consideration only if the method is used infrequently. The most important errors are: not waiting sufficiently long for the full effect of the anesthetic (fifteen minutes is the rule); not getting near enough the nerve trunk; not using a sufficiently strong solution to affect the central fibres in the nerve; failure to produce anesthesia of the lingual or buccinator nerve. The question of after-effects due to the injection is often brought up by the patient. The injection is sometimes mistakenly blamed for pains caused by the wound, but faults in technique may be the reason for certain discomforts. These, however, can be controlled. A blunt or rough needle, especially if the point is bent, may tear the tissue. If a capillary is torn, hemorrhage occurs and a hematoma is formed in the tissue. Other causes are: exerting too much pressure when injecting; injecting too fast (one minute should be consumed for a mandibular injection); using too hot or more especially too cold a solution; using a solution that is not isotonic, or contains drugs that irritate the tissue. The introduction of infection with the needle, or through contamination of the solution, must be carefully avoided.

Pre-anesthetic medication. Many patients derive a great deal of benefit from the administration of a sedative or hypnotic, especially very nervous patients and some of the poor-risk type. I often prescribe veronal (gr. V or X) the night before the operation, to assure a good night's rest; and bromural (gr. V or X) thirty minutes before the operation. Lately I have used nembutal "844" (sodium ethylbarbiturate) as a pre-anesthetic sedative, one capsule, 1½ gr. forty-five minutes to one hour before the operation.

Mandibular injection. For operations on the inferior third molar, the mandibular injection is indicated. Both the lingual and inferior alveolar nerves must be blocked. It is important that the central fibres of the inferior alveolar nerve become well saturated, as they supply the third-molar region. The soft tissue on the buccal side is anesthetized by blocking the buccinator nerve, or by local infiltration;

the latter also prevents excessive bleeding during the operation. I use a procain-suprarenin solution, freshly prepared for each patient and sterilized by bringing 3 cc. of Ringer solution to the boiling point and adding one H tablet (Metz). This makes a 2 per cent solution of procain, containing 0.5 milligram of suprarenin to each cc. One should wait at least fifteen minutes before beginning to operate; the anesthesia should last 1½ hours.

B. Nitrous-oxide-and oxygen anesthesia

I have not yet found an anesthetist who can give me, in every case, an uninterrupted anesthesia with nitrous oxide and oxygen that fulfills the five requirements. Experts who have written articles on the subject admit this. Heidbrink (6) states "that when an operation is of such a character that the operator can work better in a bloodless and salivaless field, or desires to operate under special conditions, as required in an extended operation for an impaction, nitrous-oxide-and-oxygen anesthesia may be contraindicated." Lundy (9) and Barnes (1) describe several diseases, not easy to diagnose, which present serious contraindications to the use of this anesthetic. In prolonged anesthesia such conditions must receive more serious consideration. It is true that nitrous-oxide-and-oxygen is the safest of all general anesthetics, but its seemingly absolute safety, in the face of almost indiscriminate use for tooth extraction, probably applies only to short operations. Curtis (4) and Palmer (11) believe that the drug addict, the chronic alcoholic, the patient who has fortified himself with a substantial draught before the operation, and the inveterate cigarette smoker (upwards of 20 cigarets a day), are poor subjects for this method. These patients have a high resistance, and it is almost impossible to keep them quiet long enough for a simple operation. This, of course, is my principal criticism of nitrous-oxide-and-oxygen anesthesia. Perhaps, in these days, the greater number of patients fall into one of the last two groups. The use of straps to restrain the patient is advocated; but even this method, of which many patients have a horror, is not sufficient to prevent constant motion.

Indication. Nitrous oxide and oxygen may be used for cases of third molars requiring a simple technique and not more than ten or

fifteen minutes for the operation. If the operator has any doubt about the outcome, he should refuse to operate with this anesthetic rather than take a chance at failure. Dentistry has advanced to a standing which makes it unnecessary to submit to a patient's dictation when better judgment tells us that the procedure is not expedient. Most of the operations which have been unsuccessfully terminated, and then referred to me to be finished, were attempted under this anesthetic. *Contraindications.* Heart disease is the most important. It is measured, according to Barnes (1), by the patient's response to effort. Cases of angina pectoris show greatest risk. Suspects should be asked whether they have pain in the region of the sternum, whether they show signs of fatigue and suffer shortness of breath on exertion, such as walking upstairs. If they have to sit up in bed at night to facilitate breathing, or if there are such signs as swollen ankles or cyanosis of the lips and finger tips, the administration of any anesthetic is accompanied with much danger. Other poor-risk cases are those suffering from marked arteriosclerosis, diabetes, or nephritis. Edema of the extremities, and outstanding tortuous arteries over the temporal region, are significant. For drug addicts, nitrous-oxide-and-oxygen anesthesia is absolutely contraindicated. This refers principally to the use of cocain, morphine, and heroin, but applies also to alcoholism and the inveterate smoker (11). Athletes and individuals whose occupation consists of hard physical work in the open have great resistance to this anesthetic. All patients who present a very narrow anesthesia margin are unfavorable for this method, unless the anesthesia margin be widened by premedication, according to Heidbrink (6).

Advantages. Nitrous-oxide-and-oxygen anesthesia is the safest inhalation anesthetic for cases of short duration. It can be quickly induced, and in many cases there are no disagreeable after effects. It is therefore the best general anesthetic for easy office operations. Children over six are good subjects; and those who often resist all efforts can still be handled by using force for only the shortest period of time. For younger children the choice of anesthesia should always be ether. *Disadvantages.* Very few patients remain sufficiently quiet for the use of careful technique on a difficult third molar. There are frequent interruptions, saliva and bleeding are hard to control. The latter is

always increased somewhat, owing to the increase in blood pressure accompanying nitrous-oxide-and-oxygen anesthesia. Heidbrink (6) states that even with the best care, interruptions of anesthesia are bound to occur. In cases of vomiting and persistent nausea, he recommends completion of the operation under local anesthesia at the same sitting. From an economic point of view, it might be added that the use of nitrous oxide and oxygen for long operations is expensive, and requires the service of an expert anesthetist. It is time for us to break away from the old custom of shouldering the responsibility of administering an anesthetic and performing a lengthy, delicate operation at the same time. It is not done in any other branch of surgery.

Pre-anesthetic preparation. No prolonged anesthesia should be attempted if the patient has recently eaten, or taken an alcoholic drink. Patients should be instructed not to take food in any form for at least three hours preceding the operation. Sedatives, as advised for local anesthesia, are often a great help. The cases presenting narrow anesthesia margins, and patients who are liable to become obstreperous, may be given morphia (grain $\frac{1}{6}$ to $\frac{1}{4}$) subcutaneously. In order to stop excessive flow of saliva, atropin (grain $\frac{1}{150}$ to $\frac{1}{120}$) may be added, or in other cases given separately.

C. Nitrous oxide, oxygen, ether, and intrapharyngeal ether

Nitrous oxide and oxygen, with the admixture of a sufficient amount of ether to keep the patient quiet during the operation, in many cases gives satisfaction for operations on malposed teeth. Ether alone, given by the intrapharyngeal method following the inducton of anesthesia by nitrous oxide or nitrous oxide and oxygen, is the ideal general anesthetic from the operator's point of view in cases of difficult impactions. Both methods, however, require hospitalization of the patient. The first method requires the use of a gas-and-oxygen machine with an ether attachment. There are several ways by which the ether fumes are mixed with the nitrous oxide and oxygen. The amount of ether added to the other gases varies according to the patient and the requirements of the operator. The second method consists of induction of the anesthesia by administration of nitrous oxide, or nitrous oxide and oxygen, by any of the well-known methods. When a sufficient depth of anesthesia has been reached, ether is first

administered with a cone; later a rubber tube is passed through the nose into the naso-pharynx, and the slightly warmed ether fumes are administered by means of an ether pump.

Indication. If general anesthesia is indicated or desired, ether, used as just described, gives the best result. It should always be used in difficult cases when a general anesthetic is required. *Contraindication.* The only contraindications are acute respiratory diseases, or marked constitutional diseases, in which case the family physician's opinion should be obtained.

Advantages. It fulfills the five requirements. The operator is relieved of controlling the patient's anxiety and fears. It is possible to remove four third molars at one operation, no matter how difficult, without causing psychic shock. *Disadvantage.* The method requires hospitalization of the patient, and the employment of an anesthetist and, therefore, increases the expense. In most cases, however, the patient can be allowed to go home the day following the operation. Nausea and vomiting of course are much more common afterward, but this can be greatly lessened by premedication, using drugs, such as nembutal (gr. 3). It is my custom to order the administration of 10 ounces of glucose with 60 to 90 grains of triple bromide, by rectum, as soon as the patient is back in bed.

Preanesthetic preparation. Hospital patients can be much better prepared for the operation than office patients. The patient comes more calmly into the operating room when given proper medication to facilitate the induction of the anesthesia.

IV. HOSPITALIZATION

A great many third molars can be managed as office operations, while others distinctly call for hospitalization. I do not agree with the editorial in the *Journal of the American Dental Association* (5), which suggested that hospitalization for dental operations should be discouraged. In my opinion "serious injustice" is more commonly done the patient by taking a long chance with his health, and even his life, when prolonged anesthesia is given in the office without proper preparations and facilities for after-care. Frequently the patient must travel miles to reach home after the operation. In any other branch of surgery such practice would not be permitted. If an opera-

tion requires a general anesthesia of more than fifteen minutes duration, or if ether is administered by any method, hospitalization is indicated. Other factors, however, enter into consideration, such as the distance from the patient's home, season of the year and weather, method of transportation, accessibilty for treatments at the office or visits at the patient's home, and most of all the patient's general state of health. Hospitalization is sometimes indicated in poor-risk patients, even when local anesthesia is used.

Physicians and dentists who send patients to the oral surgeon can do much to make dental surgery safer by explaining the risk of office operation and the advantages of hospitalization. I do not agree with the editorial (5) that "with most normal individuals, the idea of a hospital for the extraction of a tooth is more or less terrifying," nor "that the equipment in the average private office is superior in every way to that of a hospital for this kind of service." The openminded person will see the advantage and benefit of hospitalization. I recall many patients who were rather timid about hospitals, but became entirely converted after they had experienced the excellent care and comfort a well run modern private hospital affords. To-day most oral surgeons have special equipment in the hospitals they use. At the Brooks Hospital, where I take most of my private cases, I have a special operating room fully equipped for this highly specialized work. The operating-room nurses are accustomed to assisting me and then, also, the available private nurses are experienced in taking care of oral or dental cases. Except in rare instances involving serious complications, it is not necessary to keep the patient in the hospital very long. Most patients can go home the day following the operation, if it is performed early in the morning. I prefer having them admitted the evening before the operation, but sometimes it is advisable to have them come one or, better, two hours before the operation. They should have sufficient time to rest and quiet down before taking the anesthetic. It is, of course, necessary to instruct them in such a case regarding the proper home preparation for the operation.

V. SURGICAL TECHNIQUE

It is extremely difficult to compare the results achieved by different operative procedures. No two cases are absolutely alike. There is

also great variation in the way patients react to the operation, not to speak of the possibility of stirring up a dormant infection. Again, one operator may develop special proficiency in the use of a certain method over a long period of time, and may learn to avoid the pitfalls that undoubtedly exist, if as much force is applied by means of levers as I have seen expert clinicians use. There are certain principles in surgery that also apply to oral surgery. One should always have, if possible, a clear view of the field of operation. As little injury as possible should be done to retained tissue. A careful technique should not be sacrificed for speed. To these I would add: the operation should be planned so that the dislodgement of the tooth requires as little force as possible, to prevent injury of the second molar or fracture of the mandible. This plan also makes it possible to perform the operation with local anesthesia, without causing mental agony and surgical shock.

In developing the technique to be described I adopted, from other operators, procedures that seemed to be useful. The operation described by Kells has many points in its favor for the more difficult cases of impactions, and I evolved and adapted his idea to take care of some types of malposed third molars. C. Edmund Kells, the memory of whose friendship will always be cherished by his many admirers, was a keen observer, a just critic, a progressive scientist, and a clever operator. He first described his method before the National Dental Association in 1903. In an article written in 1918 (8), he makes the following claims for it: "With this method the patient's jaw is handled gently and the tissues surrounding the tooth are injured but slightly. Instead of chiseling the jaw away to such an extent that the tooth may be taken out whole, the tooth itself is cut." While he admits that his method is not "quick and easy," he makes the claim that it is "humane." The operation for the removal of malposed third molars involves a great deal of good judgment and surgical skill. Therefore, the operator, like an engineer, must plan the operative procedure in advance. The following rules are helpful in managing a case.

Preparation. The entire oral cavity, and especially the tissues in the region of the inferior third molar, should be carefully inspected. In a neglected mouth all sources of sepsis should be removed. Roots and teeth with fistulae should be extracted, and the patient should

receive a thorough prophylactic treatment, at a convenient time in advance of the operation. Infection of the tissue around the third molar requires special attention. In acute pericoronal abscess, irrigation with hexylresorcinol or injection of tincture of iodine into the subgingival pocket is necessary for a few days before operating. In easy cases prompt removal of the tooth under general anesthesia has the advantage of eliminating the cause and creating opportunity for most efficient drainage. If Vincent's infection is diagnosed, operation is absolutely contraindicated until the organisms have disappeared. Chronic inflammation of the gingiva, or chronic pericoronal infection between the distal surface of the tooth and the ramus or in the triangle under the mesial side of the tooth, calls for special effort in sterilization before the operation, and excision of the infected tissue after the tooth is removed. *Classification.* The case must be classified by means of careful x-ray study. It is important to be able to visualize the shape, size, position and anatomical relations of the tooth. *Choosing technique.* Choose the easiest technique indicated for the class and group of the tooth, without violating the safety factor. *Field of operation.* The field of operation should be kept clear of blood and saliva, asepsis should be maintained as far as possible under the circumstances. Operating under direct vision is much to be preferred to the old way of depending on the sense of touch. *Trauma.* It is better to injure the tooth to be removed than to cut away a great deal of tissue, which later has to be replaced by repair. While operating protect the soft tissue, by means of judicious use of retractors, against injury from chisels, elevators, and burs. An assistant may do a great deal of harm by pulling too hard on a retractor. The operator himself should use, with his left hand, an instrument that both retracts the tissue and protects it from injury. *Step method.* Clean-cut operation is more important than brevity. There is no need for hurry, but a great deal of time can be saved by completing one step at a time, which saves much unnecessary instrumentation. The operator who tries one instrument after another to elevate a tooth before the previous step is completed causes a great deal of trauma. *Application of force.* The more perfect the technique the less force is required to luxate the tooth. If abnormal force is used to offset incomplete or incorrect technique, the danger of accidents is

increased. *Protection of wound.* The healing process should not be retarded. The patient must be told that applying suction, putting the tongue into the wound, or rinsing repeatedly, disturbs the new tender tissue that is being formed. In case local anesthesia has been used, it is also important to instruct the patient to guard against biting the tongue and especially the cheek.

VI. SPECIAL TECHNIQUE

Preparation of field of operation. Immediately before starting the operation, the gingival tissue is rubbed with a piece of gauze and painted with tincture of iodine. For a partly erupted tooth, the iodine should be worked into all the crevices under the gingiva. *Incision.* The incision should be made along the postmolar triangle, starting well up on the ramus and keeping nearer the lingual side than the buccal. It should terminate 2 mm. behind the second molar. From this point it is extended over the alveolar ridge and down on the buccal side. The flap is raised with the periosteal elevator, and a place laid bare to allow execution of the chosen technique, and removal of the tooth without interfering with the soft tissue. *Retraction.* For instruments I use either a retractor, or a pointed and curved periosteal elevator. If the incision has been properly made, very little traction is necessary. The retractor should be used more to protect the tissue than to pull it away. *Direction in which tooth can be moved.* This is a simple problem of geometry. The tooth must always be moved in the direction of its main axis. A tooth with roots bent distally (group b) must be moved along the line of a circle curved distally (*fig. 7, VI b*); if the roots are bent mesialy (group c), along a circle curved mesially (*fig. 7, VI c*). *Bone resection.* A sufficient amount of bone should be removed to allow for the removal of the tooth or parts of the tooth. If the tooth is to be turned distally, a sufficient space must be created at this place. It should be remembered, especially if the tooth is in a low position, that the space should be extended sufficiently to allow the passage of the largest circumference of the tooth, which is not always the visible one. If this step has been properly completed, very little force is required for luxation. *Dissection of tooth.* When the tooth is so placed that its removal *in toto*

would injure or cause luxation of the second molar, as in *fig. 9*, or where it would be necessary to remove a large amount of bone in order to create a space into which the tooth can be turned (especially Classes Ib and IIa and b), dissection of the tooth is indicated. In some cases part of the crown is separated; in others the entire crown. The interference by the distal surface of the second molar can best be illustrated by a geometrical drawing. The projecting cusp will move along a circle, which has its center at the apex of the distal root of the tooth (*figs. 8 and 9*).

Instruments used for bone resection and tooth dissection. I prefer the use of a bur for cutting both bone and tooth. A Henahan bur with a bayonet-shaped head and specially long shaft, used in the contra-angle hand-piece, serves both purposes. If it is new it cuts extremely fast; and as only one bur is used for each operation, it can be thrown away after use. Those who object to the use of burs for cutting bone can use a chisel or ossisector, and reserve the bur for tooth dissection. In the use of the bur technique, I have never experienced any of the bad results mentioned by some of the opponents of this method. The orthopedic surgeon uses burs. Why should not we? The man with dental training should certainly be able to use burs without getting entangled in the soft tissue or producing undue heat (generally caused by the use of dull burs). The bur cuts bone quicker and more accurately than any other instrument. With the bur it is possible to cut a groove around the distal part of the crown without injuring the external and internal alveolar plates. For tooth dissection only one other instrument should be considered; namely, Smith's lever drill (13). This is an excellent instrument, but it has to be applied from the buccal side, and in deeply placed teeth requires breaking through the external cortex of the mandible. The proper sterilization and care of the *handpiece* is, of course, of great importance. After use, the bur is removed and the handpiece scrubbed with soap and water; it is then attached to the engine and run while inserted, first into a bottle containing Solubri cleanser; second, into a bottle containing engine oil; after which it is sterilized in a handpiece oil-sterilizer. When the instruments are prepared for the operation, the handpiece is fitted with a bur. If two sizes of burs are required, two handpieces are mounted rather than to change burs while operat-

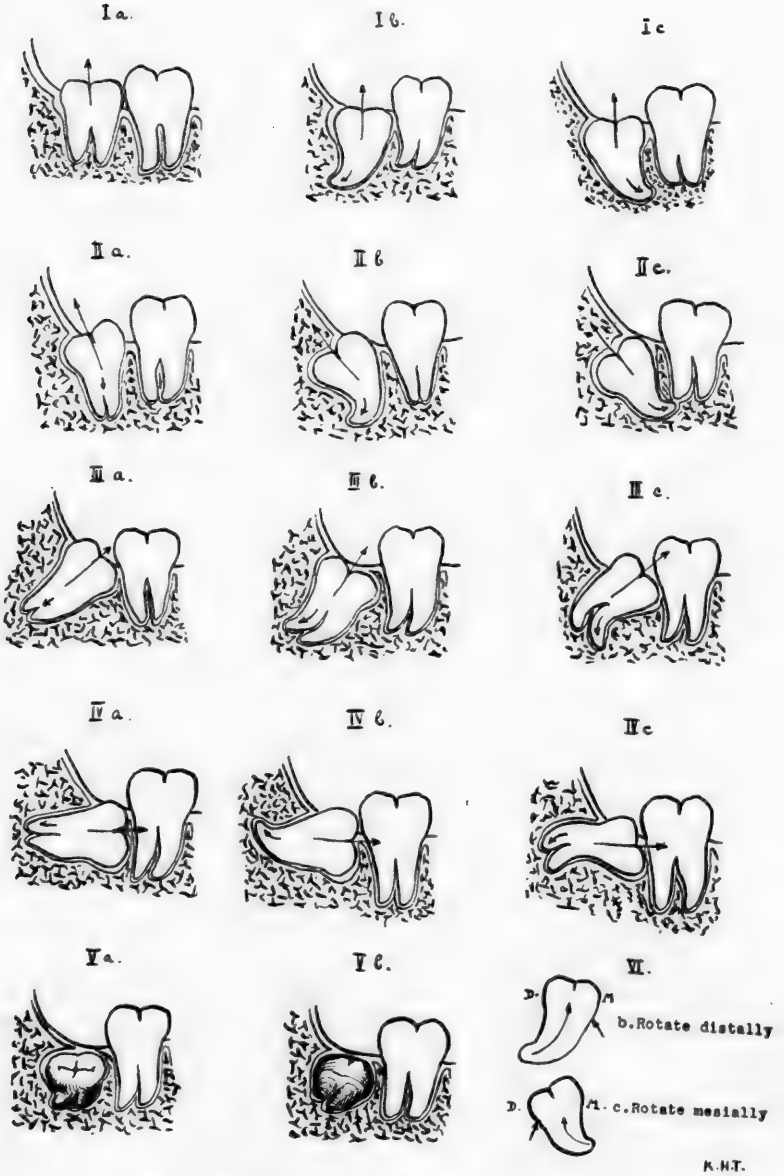


FIG. 7. Different classes of malposed inferior third molars

ing. The handpieces with the burs are then placed into a tray containing alcohol until used for the operation.

Luxation of tooth. After the obstructions are completely removed,

FIG. 8

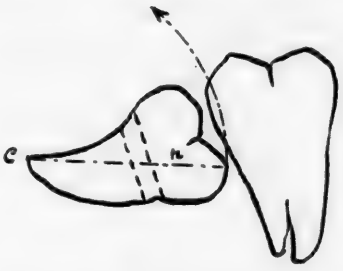


FIG. 9

FIG. 8. Tooth can be rotated; r = radius, c = center, of circle that does not interfere with second molar.

FIG. 9. Tooth should be bisected; r = radius, and c = center, of circle that describes path of mesial cusp of third molar when rotated. Tooth forced in this direction causes luxation of second molar (*fig.* 5).

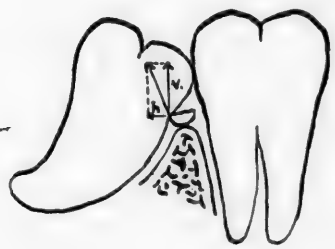


FIG. 10

FIG. 11

FIG. 10. Division of force applied by bayonet elevator; v, vertical component, greater than h, horizontal component. Force applied in this manner causes vertical luxation of third molar.

FIG. 11. Division of force applied by bayonet elevator; v, vertical component, much less than h, horizontal component. Force applied in sufficient strength fractures mandible.

the tooth or the dissected parts thereof can be luxated and removed. A certain amount of force is required to accomplish this, but more important is the application of this force at the right place, which is the

convex side of the tooth. The direction in which the applied force becomes most effective is illustrated in *figs. 10* and *11*, showing the division of the force along its horizontal and vertical component. When the force in the vertical direction is greater than in the horizontal, the tooth is moved upward (*fig. 10*). When the reverse occurs, the mandible is fractured (*fig. 11*). Luxation of the roots after the crown has been removed is extremely simple, but varies according to the curvature at the apex. The technique for the different classes of teeth is given later. *Instruments used for luxation.* An enormous number of elevators and exolevers have been designed for the removal of the inferior third molar. It is impressive to have a large array of instruments on the table, but it is possible to get along with a very small number. Powerful levers are excluded, because they are neither needed nor wanted. For the rest, each operator selects the type that suits his requirements. I use a bayonet elevator, a pair of Miller's displacement instruments (Ivory ⅋1 and 2), a pair of Cryer elevators (Clev-dent ⅋30 and 31), and a pair of Heidbrink apical elevators (Friedman ⅋98 and 99).

Removal of tooth. After the tooth is luxated it can, as a rule, be easily removed. In some cases Ash's forceps (*fig. 19*) can be used; but in many, the tooth or dissected parts are removed with ordinary dressing forceps (pliers). *Inspection of wound.* The next step is to inspect the wound. All debris, loose bone (such as fractured septum between the roots), remnants of the enamel organ (to prevent the formation of a cyst), and infected gingiva, or granulation tissue should carefully be removed. Projecting points and sharp edges of the bone should be planed. This can be accomplished with a large round bur as ordinarily used for vulcanite work. *Closure of wound.* Sterilization of the wound is not necessary except where infection is present. In such cases I dry the wound with a sterile sponge, and swab it thoroughly with a piece of gauze saturated in full-strength hexylresorcinol. In all cases I see to it that a blood clot forms. This is at once protected either by suturing the flap into place, leaving an opening for irrigation, or in most cases by placing a sterile sponge on the wound and directing the patient to apply pressure for about fifteen minutes by closing the teeth against it. This also prevents otherwise troublesome bleeding while the patient returns home from an office operation.

In cases complicated by acute infection and suppuration, it is advisable to insert a drain into the wound.

Accidents to be guarded against. In the use of levers, especially if a great deal of force is applied, the tissue used as a fulcrum is sometimes injured. If an exolever is used between the second and third molars great care should be taken that the alveolar crest around the root of the second molar is not interfered with. In attempting to remove a tooth impacted under the crown of the second molar without dissection, the great force applied may either lift the second molar slightly out of its socket and injure the dental vessels entering the apices; or, by causing back pressure, may result in crushing the wall of the mandibular canal, causing parasthesia. Injury of the alveolar nerve may also be caused by pathological conditions resulting from pulp and periapical infection following surgical trauma in cases where the roots are formed around the mandibular canal, and by instrumentation.

VII. SELECTION OF SPECIAL TECHNIQUE FOR THE DIFFERENT CLASSES OF MALPOSED INFERIOR THIRD MOLARS

Class I, vertical position

Class Ia and Ib high position. Teeth belonging in Class Ia and Ib, in high position, can be removed by placing a bayonet elevator under the mesial surface of the third molar. Rotate it so that the sharp lower edge applies force in as much of a vertical direction as possible, and the tooth will be luxated so that it can be removed. If the space between the second and third molars is not sufficiently large to allow the use of this type of elevator, without injurying the bone around the second molar, use the technique for teeth in low position. *Class Ia and Ib low position.* Teeth belonging to Class Ia and Ib in low position require, first, resection of the bone overlying the crown of the tooth. In Class Ib it is also necessary to resect some of the bone at the distal surface of the tooth, to form a groove to allow for a slight distal rotation. In cases with extreme curvature of the roots the distal part of the crown is cut off (*fig. 14*). If necessary, remove the superior part of the buccal plate to gain access to the cervical margin of the buccal surface of the tooth. Here is drilled a hole of sufficient size and depth to engage a Cryer elevator. Using the thick cortical

bone as a fulcrum, the tooth is luxated by a twist of the elevator and removed (*figs. 12 and 13*). *Class Ic, high and low position.* Teeth belonging to Class Ic are not very common. After removing the bone overlying the deeply placed tooth, we cut away the mesial part of the crown (*fig. 15*). This creates a space that allows for slight mesial rotation. The same technique is used as for class Ia, deep position.

Class II, disto-oblique position

Class IIa, high and low position. This tooth must be removed in the direction of its axis. In order to clear the path it is necessary to remove the part of the ramus that generally covers the distal part of the occlusal surface of Class II teeth. Otherwise, the same technique is employed as for Class Ia, low position. *Class IIb, high and low position.* This perhaps is the most difficult type. Very marked curvature of the roots necessitates a great deal of room at the distal side for the tooth to escape. Dissection of the entire crown or the distal part of it saves extensive bone resection. After removing the fragment or the crown, force is applied at the mesial surface, which luxates the remainder of the tooth sufficiently to allow its removal (*fig. 16*). *Class IIc, high and low position.* This condition, like Ic, is also more or less rare. It is often necessary to remove an appreciable part of the ramus in order to get access to the tooth. Sometimes it is possible to use the technique for Class Ia, low position; at other times three quarters of the crown are removed first as for Class IIb.

Class III, mesio-oblique position

Class IIIa and IIIb, not impacted. This type in low position requires first the removal of the bone over the crown of the tooth and, in both high and low position, a sufficient amount of bone at the distal side of the tooth to allow the tooth to escape in a distal direction when force is applied under the mesial side. A bayonet or Cryer elevator may be used for the purpose. In deeply placed teeth, the buccal plate must be removed at the place where the instrument is to be inserted (*fig. 18*). After successful luxation of the tooth, it is removed (*fig. 19*). *Class IIIa and IIIb, impacted.* Dissection of the mesial part of the crown is indicated both in high and low position (*fig. 17*). Otherwise the operation is the same as for Class IIIa and IIIb, not

impacted. *Class IIIc, high and low position.* Teeth in this class, whether impacted or not, or in high or low position, call for dissection of the entire crown, because the curvature of the roots contraindicates application of force at the mesial surface of the tooth. The same method is used as that described below for Class IVc.

Class IV, horizontal position

Class IVa, IVb and IVc, high and low position. All cases of Class IV are treated alike. Exception may be made for an occasional very short tooth of the Class IVa and 1Vb type in high position, if there is room enough to rotate it without disturbing the second molar (*fig. 8*). It is then treated like Class IIIa and IIIb, not impacted. In the typical case the superior distal surface of the crown is exposed as far as the neck of the tooth, where vertical holes are drilled through the entire tooth. It is not necessary to penetrate the inferior side, but it is an advantage to connect the holes, to create a space between the crown and root the width of the bur (*fig. 20*). This space facilitates luxation and removal of the dissected crown, which is accomplished with Miller's displacement instruments, or Heidbrink's elevator. Sometimes a Cryer elevator is inserted into the pulp chamber to extract the crown. The technique for the removal of the roots depends, to some extent, on their formation and curvature. In Classes IIIc, IVa, and IVc, where the roots are straight or curved downward (mesially), a hole is drilled vertically through the bone and into the superior side of the root. By inserting a Heidbrink root-elevator into this hole the root is dislodged from the socket with a slight motion, using the bone as a fulcrum (*fig. 21*). For a multi-rooted tooth, with the roots separated, this operation may have to be repeated, if the lower root is not dislodged with the superior one. In Class IVb, where the roots are curved distally, they can generally be removed more easily by inserting a Cryer elevator into the pulp chamber, and applying force in a forward and upward direction.

Class V, transverse position

Most cases in Classes III and IV show slight deflection to the mesial or buccal side, but in some instances the long axis of the tooth lies in a plane representing a frontal section through the head. This

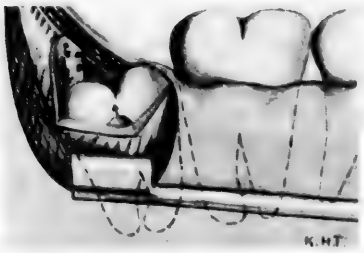


FIG. 12

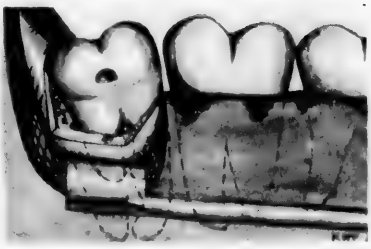


FIG. 13

FIG. 12. Class Ia. After incision, bone over tooth is exposed and sufficient amount removed to allow room for largest diameter of tooth to pass.

FIG. 13. Class Ia. Tooth luxated by applying elevator in hole drilled into buccal surface of tooth.

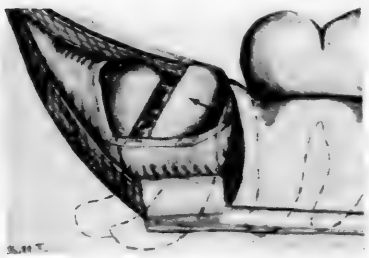


FIG. 14

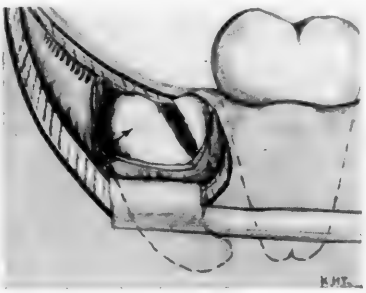


FIG. 15

FIG. 14. Class Ib. Distal part of crown dissected

FIG. 15. Class Ic. Mesial part of crown dissected

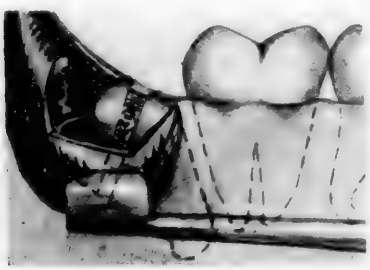
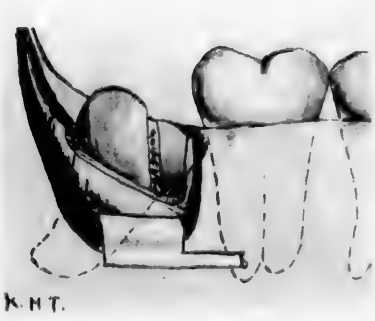


FIG. 16. Class IIb. Large part of crown dissected



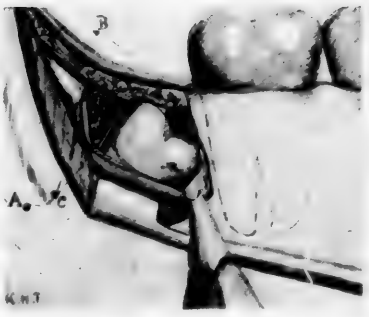
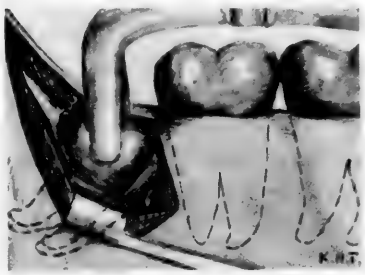


FIG. 17 FIG. 18

FIG. 17. Class IIIb. Mesial part of crown dissected.

FIG. 18. Class IIIb. Crown exposed and sufficient amount of bone resected distally to allow rotation of tooth in direction of circle *B*. Center of circle at apex of distal root (*A*); when tooth is luxated, center moves to *C*.



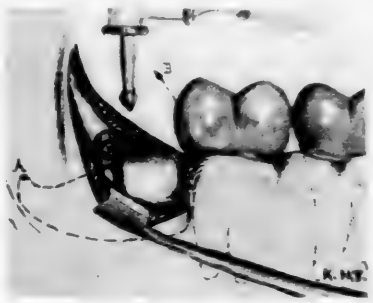


FIG. 19 FIG. 20

FIG. 19. Class IIIb. Removal of luxated tooth.

FIG. 20. Class IVb. Tooth bisected with bur. Space between two parts facilitates removal of crown without danger of luxating second molar. *B*.—Circle mesial cusps would describe if tooth were removed *in toto*. *A*.—Center of circle.

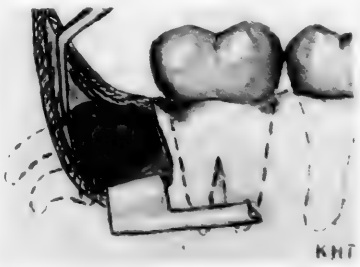


FIG. 21. Class IVc. After removal of crown, roots are luxated

position of the tooth is best diagnosed with an occlusal x-ray picture. The occlusal surface may face the buccal side (buccal position), or the lingual (lingual position). It may be in an oblique or horizontal position. *Class Va, buccal position.* Very seldom are teeth in this class in an entirely horizontal position. They are removed like Class Ia, deep position. *Class Vb, lingual position.* If in an almost vertical positon, the technique for Class Ia is used. If decidedly oblique or horizontal, sufficient bone is removed to dissect the crown at the neck of the tooth. After it is removed, the roots are taken care of as for Class IV. When removing the crown, care should be taken not to apply force toward the lingual side, which would cause fracture of the lingual plate of the alveolar process.

VIII. POST-OPERATIVE CARE

In order to understand post-operative care it is necessary first to *know how the wound heals* after removing a malposed inferior third molar. After operative procedures cease, a blood clot forms in the wound. If there is not sufficient bleeding, the operator should stimulate bleeding with the use of a suitable instrument. Capillary loops soon form in the clot, furnishing nourishment to the different cells and the clot is said to become organized. These capillary loops are principally formed from the disconnected dentinal arteries at the end of the alveolar sockets, and to some extent from the remnants of the peridentinal membrane lining the bone. After an ordinary tooth-extraction, the blood clot is small—the size of the alveolar socket of a root. After removal of an unerupted third molar, a relatively enormous cavity has been created by the removal of roots and crown, and the resection of more or less bone. As the bone has poor power of reparation, the blood clot is generally well nourished in the lower part only. After 24 to 48 hours it becomes necrotic in the upper part. The continuation of the healing process from then on is, therefore, by second intention. Granulation tissue forms slowly until there is but a slight depression; finally epithelium grows over it. Until the wound is protected in this manner, it has to be taken care of by the treatment described below.

Swelling. Swelling of the face over the third-molar region, and extending to the submaxillary region, is not uncommon. Swelling

on the lingual side of the jaw, which should not occur with the technique described, is due to injury of the lingual plate, and produces difficulty in swallowing. Swelling is generally caused by mechanical injury in the operation, and varies greatly in different patients. Careless instrumentation, of course, is an augmenting factor, but many patients get an enormous amount of swelling from a slight injury. Bruises and even ecchymosis may appear on the face from pressure caused by the hand supporting the angle of the jaw. In cases of partly erupted teeth, dormant infection may have become active, causing the swelling that sometimes extends to the buccinator or internal pterygoid muscles, causing trismus, the patient being unable to open the jaw or only partly so. Of course, trismus may also be caused by a faulty mandibular injection.

Pain. A certain amount of wound pain must be expected. It may be felt in any part of the face or head, and especially in the ear. Pain is greatly augmented by mechanical irritation from small spicules of loose bone, fractured alveolar process, rough margins, or exposure of unprotected bone. If there is numbness in the incisor teeth and lower lip, the inferior alveolar nerve has been injured, but the patient may feel at the same time an ache or darting neuralgic pain originating in the part of the alveolar nerve distal to the injury. A dry socket produces a great deal of pain, as does bone that is exposed when part of the blood clot has been lost. Exposed bone is highly sensitive, and disposed to infection. The necrotic part of the blood clot should, therefore, be promptly removed; and if sutures have been used, an opening should be left for removal of the broken down tissue. Pain generally disappears just as soon as the bone is covered by granulation tissue. Infection in itself is a common cause of after-pain. It may have been present before the operation, or introduced during the operation; or it may find its way into the wound during the process of healing. Renewed swelling and pain after the wound has practically healed is generally due to the formation of a sequestrum. It may be a piece of bone cut off from nutrition, or a fragment that escaped notice, such as the septum between divergent roots.

Treatment. The patient should be told what to expect in the way of after-effects. It is much more satisfactory to have patients get along much better than anticipated, than to have them fearful be-

cause they find themselves suffering from complications they did not expect. *Care after operation.* The hospitalized patient, after operation with general anesthesia, receives at once a glucose-bromide enema (10 ounces of 10 per cent glucose solution with 60–90 grains of triple bromide). If the operation was very difficult, or involved the removal of several impacted teeth, codein (grain $\frac{1}{4}$ s.q.) is given in addition. Routine care is described below. The office patient is given a sedative just before the dressing is placed on the wound. Anacin (two tablets), or aspirin (grains X), or empyrin compound (empyrin gr. $3\frac{1}{2}$, phenacetin gr. $2\frac{1}{2}$, coffeine gr. $\frac{1}{2}$; two tablets) prevents the first wound-pain which is felt otherwise after the anesthesia disappears. The patient should be told to repeat the sedative after the effect has worn off. Occasionally, when there is a great deal of pain, especially at night, veronal (grains X) or nembutal (two capsules, grains $1\frac{1}{2}$ each) should be given. In order to control swelling, cold applications should be started as soon as the patient gets home. The intermittent application is best—one-half hour on and one-half hour off, for about five hours. If the patient has a great deal of swelling, in spite of everything, the treatment should be continued for several days. The wound should be disturbed as little as possible. No mouthwash should be used the day of the operation. Repeated rinsing disturbs the blood clot, and often produces hemorrhage. If there is bleeding, a new pack should be placed on the wound and pressure applied for fifteen minutes. If this does not control it, apply ferric subsulphate (Monsel's salt) in powder form on a small piece of gauze, placing the larger dressing on top. The packing is removed two days later. On the day of the operation, the patient should rest at home, and subsequently should refrain for a period from violent exercise. After the second day, a warm mouthwash should be used several times a day.

Follow-up treatments. On the second day the patient's reaction to the operation is generally evident, and treatment can be undertaken accordingly. In many cases mild irrigation of the wound until it is healed is sufficient. Salt solution, with or without the addition of iodine, 4 per cent boric acid solution, or any other mild antiseptic solution, serves the purpose. After a certain time the patient can be given a syringe with which to conduct the washing at home, because

later it is merely necessary to remove food masses that gather in the socket. If there is a slight discharge and odor, apply tincture of iodine, or Churchill's iodine and glycerin, on a saturated swab to the previously dried socket. While the open method of treatment is to be preferred, certain cases require dressings. Dressings are applied for three purposes: to protect the wound, to apply an antiseptic having a lasting effect, and as a carrier for a local anodyne. In cases of dry sockets or where a large portion of bone is exposed, protective dressing is indicated. Iodoform gauze or, if there is objection to the odor, mercurochrome gauze dipped in liquid petrolatum, or saturated with vaseline and lightly packed, is used. The following anodynes may be applied on the dressing: Guaiacol and glycerin (equal parts), aftex paste, procain paste (15 percent) in a lanolin base containing benzoin and thymol iodid recommended by Puterbaugh (12), or a paste made of camphophenique, glycerin and aspirin powder, as used by Kazanjian (7). Dressings soon become contaminated in the mouth, both from wound secretions as well as from food and fluids from the mouth and, therefore, should be changed every day. Before a new dressing is inserted, the wound should be irrigated. In cases of dry sockets, healing may be hastened by light curetting of the socket to stimulate slight bleeding, but in other cases the granulating wound must not be disturbed. After the treatment with dressing has accomplished its purpose, it should be discontinued because the wound heals more quickly by the open method.

47 Bay State Road

IX. REFERENCES TO LITERATURE

(1) BARNES, A. R. 1926. Quotation from paper by Lundy, John G. (9, below).

(2) BLUMENTHAL, FRED. 1928. The advisability of a complete and periodic radiographic examination of all orthodontia cases. *International Journal of Orthodontia and Oral Surgery*, p. 894; October.

(3) COOKE, JOHN W. 1929. Relation of exodontist to general dentistry. *Journal of the American Dental Association*, p. 1418; August.

(4) CURTIS, LAWRENCE. 1927. Physical examination of patients before extraction of teeth under general anesthesia. *Ibid.*, p. 458; March.

(5) Editorial. 1928. Hospitalization for dental operations. *Ibid.*, p. 564; March.

(6) HEIDBRINK, JAY A. 1931. General anesthesia, its use in the practice of exodontia and oral surgery. *New York Journal of Dentistry*, p. 62; February.

(7) KAZANJIAN, V. H. 1928. The treatment of postoperative complications. *Dental Cosmos*, p. 135; February.

(8) KELLS, C. EDMUND. 1918. Impacted lower third molars. *Dental Cosmos*, p. 101; February.
(9) LUNDY, JOHN G. 1930. Anesthesia for dental operations. *Ibid.*, p. 1012; June.
(10) OTTOLENGUI, RODRIGUEZ. 1927. Pathological conditions discovered within the pulps of unerupted, impacted and imbedded teeth. *Dental Items of Interest*, p. 248; February.
(11) PALMER, BISSELL B. 1925. The choice of the anesthetic in oral surgical operations. *Ibid*, p. 432; June.
(12) PUTERBAUGH, P. G. 1930. Removal of impacted teeth under conduction anesthesia. *Journal of the American Dental Association*, p. 711; April.
(13) SMITH, EDGAR W. 1930. The classification and technique for the removal of mandibular third molars. *Dental Items of Interest*, p. 929; December.
(14) THOMA, KURT H. 1922. Oral roentgenology II; Lea and Febiger, Philadelphia, Pa.

STUDIES IN PRACTICAL DENTAL EMBRYOLOGY

I. Preliminary Data

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I. INTRODUCTION

During a recent trip abroad, the opinions expressed by some medical and dental practitioners regarding the research worker in pure dental science were a source of some surprise to me. The medical man generally has a fair idea of the exacting and painstaking methods employed by those of his confreres who devote their time to investigations in scientific medicine. Many dentists, on the other hand, seem to be unfamiliar with what goes on "behind the scenes." Both groups have a very distorted conception as to how the dental research worker occupies his time. Apparently he can justify his existence if he develops, for example, a new and quicker way to construct a prosthetic appliance at a reduction in cost. But what does it all mean, when one is working with paraffin microtomes, chemical formulae, and such like? This series of articles is presented to correct misapprehensions, and to interest those who may be unfamiliar with the procedures of research in embryology. The newer school of dentists, as well as many in the old, are aware that modern dental practice is, or should be, established upon a biological basis. Detailed knowledge of this

basis is often distorted, with regard to cytological studies, owing to ignorance of the practical procedure necessary in treating a part for examination. Perhaps it is not really surprising that the average dental and medical practitioners know little of cytological technique. This situation can be attributed to limitations occasioned by the pressure of more urgent subjects in curricula which are already overloaded, leaving little or no time for elective studies along these lines.

In this series of articles we shall deal with the microscopic study of the dental apparatus in the human embryo. No new beliefs or theories are offered, but stress is laid upon the consideration of the subject from the laboratory aspect. In other words, hypothetical standards are disregarded, and observations are reported on the basis of findings as shown secondarily to a precision technique. We do not intend to treat the whole phase of dental development, as this is adequately covered by many excellent text books. But we have selected a representative series of human embryos portraying the different stages of tooth and jaw development, and will discuss the interesting points portrayed by microscopical section, in terms of laboratory technique and the subject's past history.

II. MATERIAL AND COLLECTION OF DATA

In the collection of material, it is of paramount importance that we, as dental scientists, use a method similar to that employed by the most advanced embryologists, so that our findings will rest upon a common basis. The first requisite to this end is an accurate compendium of data from which to establish the embryo's age, and those other factors that affect interpretation in terms of normality.

Two years ago, when our collection of human embryos was begun, we were advised by Prof. F. T. Lewis of Harvard to adopt the method of Prof. G. L. Streeter (1) of the Department of Embryology, Carnegie Institution of Washington, for the determination of weight, size, and age. This we did. Now, after two years of practical use, we find Streeter's tables and graphs indispensable in our studies.

III. FIXATION

Fixation of the embryo is necessary to preserve the material, and must be accomplished as soon after somatic death as possible, to

prevent any post-mortem change in tissues. To this end we have the coöperation of the clinical staffs in the institutions where the greater number of our embryos are collected. These clinicians, after obtaining the embryos, place them in a fixative—now, almost without exception, 10 per cent formalin. Streeter's tables and graphs are also based on this fixation. In the various hospitals and institutions that collect our material, we have jars of this fixative. Attached to each of them is a tag, the form of which is shown as section *A* in *fig. 1*. This simple form affords the necessary information without requiring the clinician to resort to much clerical detail—a condition of importance in busy hospitals. This form is completed by insertion of the hospital case-number, the time and date the embryo is placed in fixative, and the elapsed time before being placed therein.

With formalin fixation, Streeter found that fresh tissues rapidly take up the solution, which causes the embryo to become somewhat distended with a slightly increased weight. He also noted and states that after a period of time in the fixative, the embryo returns to normal weight and size. Our observations agree with those of Streeter. We therefore endeavor to be present at the time of delivery, make the measurements, and take the weight of the fetus before fixation. Where this is impossible, measurements and weight-taking are delayed until at least two weeks after fixation, when return to the normal dimensions occurs. We have used various fixatives to compare the resultant slides with those made after fixation in 10 per cent formalin. Our results have shown that divergence from the standard method is not justified. Therefore we have no hesitancy in stating that a 10 per cent formalin solution is the most practical fixative for dental embryological studies. It can be readily made, standardization is sure through its stability, and it is almost universally available.

IV. MOTHER'S HISTORY

In all large hospitals every patient is designated by a case number, and it is most important that this be procured on form *A*, as previously described. Having this number, a member of the laboratory staff can then obtain the details as required by form *B* in *fig. 1*. These details can be collected from the hospital records at any convenient time. The data are simple, to the point, and do not entail much

HOSPITAL CASE NO..... DATE.....

HOSPITAL OR SOURCE WHEREBY OBTAINED.....

A

Fixation	Time elapsed	Time placed in fixative	Fixative
of	Immediately	.....AM	5% Formol
	30 minutes	.....PM	10% "
	60 minutes		Formolalcohol
Embryo	Longer	Date.....	

B

Mother.... Married..... Age.....years Race..... Weight.....
Unmarried.....
Height.....
Primipara.....
Multiparae..... living..... dead.....
Miscarriages.....
Hospital Case No. ..... Reason for Delivery.....
State of General Health.....
.....
.....
Laboratory Case No. ..... State of Oral Health.....
.....
Attendance at Prenatal Clinic Yes
No
No data
Date of last menstrual epoch.....
Stated menstrual age.....days
Remarks and additional data.....
.....
.....

C

Condition of Embryo..... Sex.....
(Streeter's Grade I, II, or III)
Weight in grams..... Head modulus in mm.....
C. R. length in mm..... Established age.....days
Date placed in 80% alcohol.....
Photographed.... before fixation.....date X-rayed Yes
after fixation.....date No

Date	Parts Used	Purpose	Signature

FIG. 1. BLANK-FORM FOR RECORDS

time in compilation. This section of the chart is self-explanatory; the significance of the various items, and their bearing upon dental studies of the oral tissues, will be discussed later.

V. GRADING AND MEASUREMENT OF EMBRYO

Having completed sections *A* and *B* of the blank-form in *fig. 1*, we proceed with section *C*, relating to the laboratory work, which is performed independently of sections *A* and *B*. The condition of the embryo is indicated in terms of Streeter's grades: *Grade I.*—No injury to tissues; immediate fixation. *Grade II.*—Slight injury to tissues; fixation not immediate. *Grade III.*—Some maceration of tissues through mechanical injury; elapsed time before fixation indefinite. These facts are tabulated, as we use only Grades I and II for histological study. Grade-III cases, where the head has not been unduly traumatized, are used for macroscopic study under micro-dissection. Note is made of sex in the older series where it can be determined. The weight of the embryo, in grams, is recorded and, if possible, is noted before fixation, because the rapid taking-up of the formalin solution by the tissues increases the weight and length, as previously stated.

VI. AGE DETERMINATION BY MEASUREMENT

It would be relatively easy to determine the age of human embryos, if the time of conception could be definitely established. Unfortunately, the moment the spermatozoon enters the ovum cannot be computed. Fertilization does not of necessity follow immediately after copulation. The period of gestation is usually computed from the end of the last menstrual epoch. The date of this starting point from which to calculate is not clinically easy to obtain. Some women menstruate once or twice after the onset of pregnancy; some give false dates in response to questions; others, having forgotten the date, make wild guesses as to the facts. These conditions make it obvious that an accurate direct method to determine the age of embryos must be used. The age of embryos is now determined, not in terms of days, but by measurement between two predetermined, fixed, and constant points. This method was worked out by Mall. The reader is referred to his Manual (2) for details. As we follow the teaching of Streeter,

the only measurement of Mall's applicable in our case is the crown-rump length (sitting height); this measurement, easily made, is applicable to the smallest embryos.

VII. METHOD OF MEASURING EMBRYOS

The crown-rump ("C. R.") measurement of Mall is the distance between a point immediately over the mid-brain to the lowest point on the surface of the breech. These points are shown in *figs. 2* and *3*. The measurement, C. R., in millimeters, is obtained with spreading calipers (Tasterzirkel of Martin), as explained by Schultz (3). These calipers (*fig. 5*) are made by P. Hermann, Zurich, Switzerland. To record the C. R. measurement of the older fetuses, we use a modification of the measuring board of Schultz, as it can be more accurately and conveniently established with this simple apparatus than with the calipers. Furthermore, the true relationship of head to body is retained in the sitting height (crown-rump length).

At times we receive embryos of which, owing to traumatization, the C. R. measurement cannot be determined with accuracy. Where this involves only the body, we can, in many cases, determine age through the head modulus (Streeter). According to Streeter the head modulus is "expressed in millimeters, and consists of the mean between the greatest horizontal circumference of the head and the biauricular arc." This measurement is taken, with thin strips of paraffined paper, from the external meatus on one side, over the apex of the head to the external auditory meatus on the other side. These strips are also used to determine the head circumference.

VIII. DETERMINATION OF AGE FROM WEIGHT, "C. R." LENGTH, AND HEAD MODULUS

The weight of the embryo is also taken, and the resultant checked against the crown-rump length and the head modulus. With these three factors in our possession, by plotting along the curves in Streeter's charts (*figs. 6, 7, 8, and 9*), we determine the menstrual age in weeks. To use an example, *fig. 4* shows a fetus with C. R. of 178.0 mm., a head modulus of 160.5 mm., and a weight of 401 grams. The graph in *fig. 6* takes us past the twenty-first week of menstrual age,

FIG. 2.

FIG. 3.

FIG. 2. Human embryo × 2. C. R. = 29.5 mm.
FIG. 3. Human embryo × 2. C. R. = 28.75 mm.

FIG. 4.

FIG. 5.

FIG. 4. Human fetus. C. R. = 178 mm. H. M. = 160.5 mm. Wt. = 401 gm. Age = 149 days.
FIG. 5. Spreading calipers used for measuring embryos.

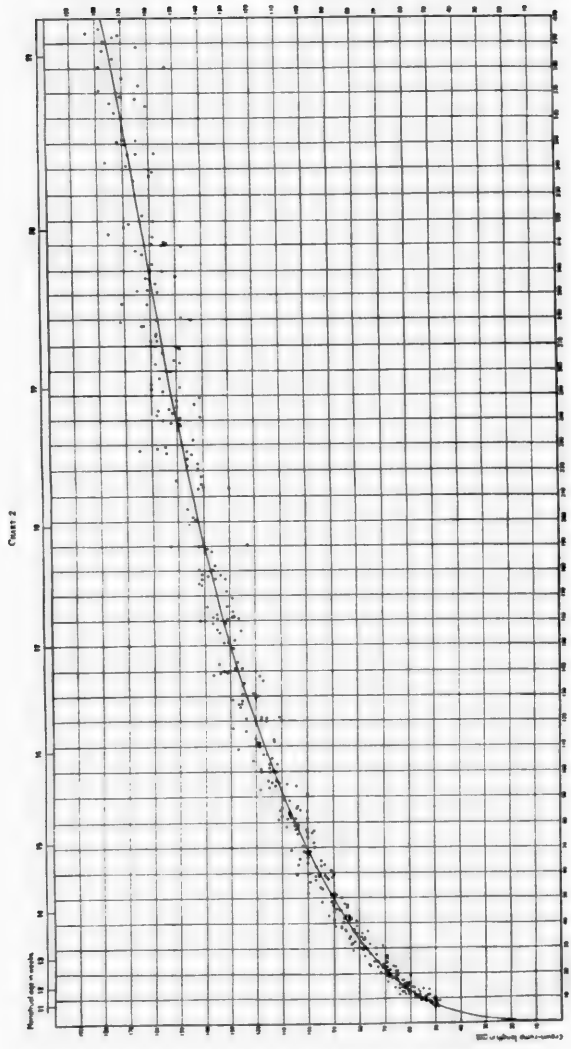

FIG. 6. Mean curve of growth for fetuses, of the Carnegie Collection, weighing less than 400 grams; based on sitting height and weight (Streeter).

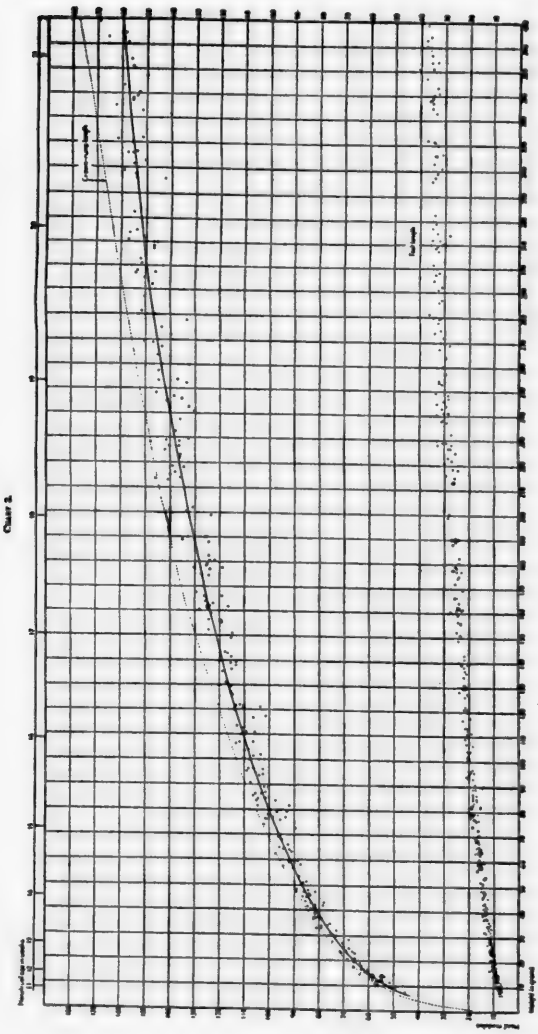

FIG. 7. Foot length and head modulus correlated to sitting height and weight for fetuses under 400 grams in weight. The heavy line represents the curve of the mean head modulus; the broken line, the mean sitting height or crown-rump length taken from *fig. 6* (Streeter).

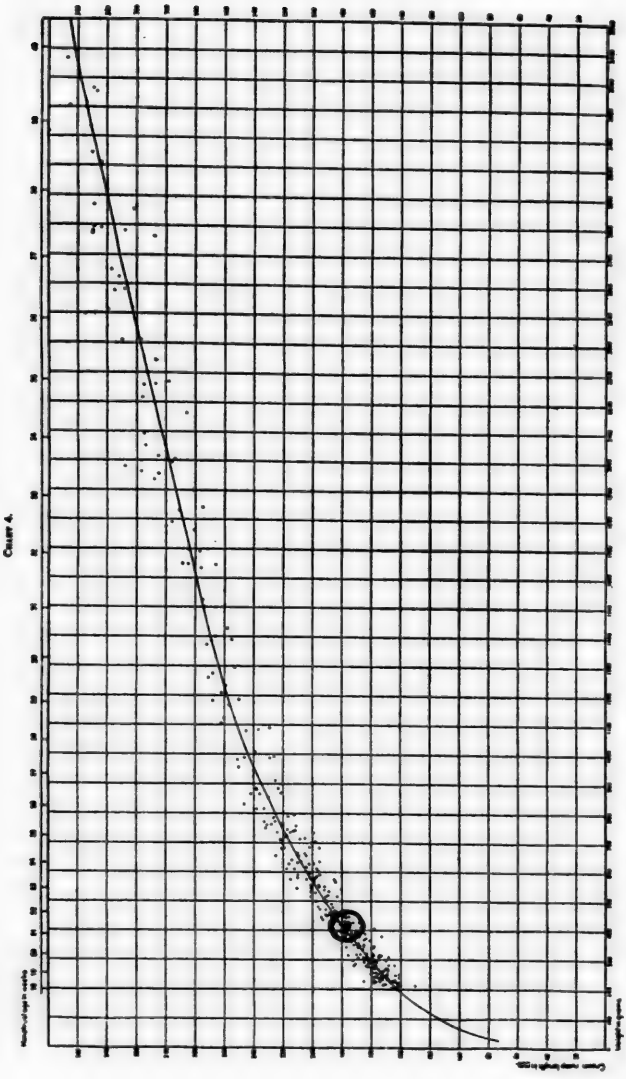

FIG. 8. Curve of growth for fetuses, of the Carnegie Collection, over 200 grams in weight, plotted for sitting height and weight (Streeter). ⊙ marks age of embryo in *fig. 4* (C. R., 178 mm. and wt., 401 gm. = 149 days).

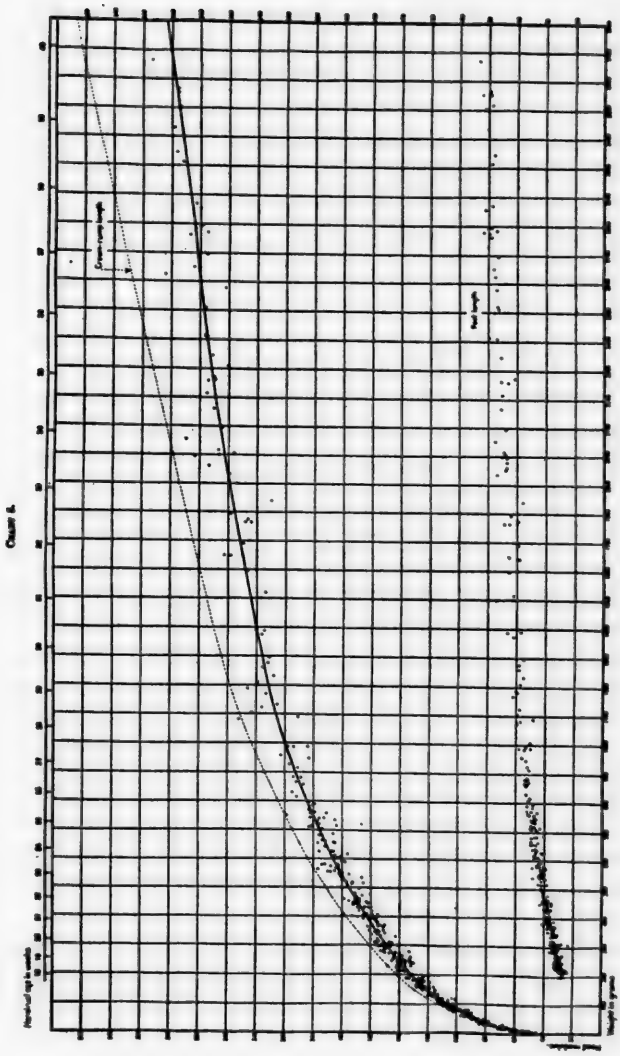

FIG. 9. Foot length and head modulus correlated to sitting height and weight for fetuses of the whole pre-natal period. The heavy line represents the curve of the mean head modulus; the broken line, the mean sitting height or crown-rump length taken from *fig. 8* (Streeter).

working with embryos weighing less than 400 grams. On the chart, (*fig. 8*) we plot C. R., 178; check with the weight, 401 grams; and obtain the menstrual age, 149 days. Let us assume that, on account of trauma, it was impossible to obtain the true C. R. of this embryo (*fig. 4*), and we were compelled to work by the weight, or the head modulus, or both. The injury to the tissues, in all probability, would not have affected the weight, so we still would have two factors to use, checking one against the other. By using *fig. 9*, the head modulus of 160.5 and the weight of 401 grams would give the menstrual age as 149 days—the same as that obtained by using the C. R. factor.

IX. COMPLETION OF DATA TO BE FILED

The age having been established, the embryo is photographed and x-rayed. X-rays of the younger embryos may not be important; but in the older ones, after dental calcification has begun, they correlate the growth and calcification of the dental apparatus with the ossification in the other bones in the skeleton. The photograph is usually taken to scale, which is noted, so that if an argument should arise as to any measurement, or the grade of the embryo, the photograph would present conclusive evidence. The embryo is stored in 80 per cent alcohol, in glass jars labelled with the laboratory case number. The form shown in *fig. 1*, together with photographs and x-rays, are filed for future use. The lower part of section *C*, *fig. 1*, records the material used by various members of the Research Department, thus helping to prevent waste, and to indicate the urgency of replenishing certain age-groups. It also serves as an added check for the individual scientist in comparing his slides with the form data, in the event he loses or misplaces the laboratory case number from which his material was taken.

The foregoing represents, in a general way, the method of procuring both material and data, the first essential to a systematized and thorough investigation of tooth development in the human embryo. We shall endeavor, in the succeeding articles of this series, to throw a little light upon the factors that influence the normal development of the dental apparatus in man, by utilizing the "extra-parental" data and applying them in terms of biological significance.

X. REFERENCES TO LITERATURE

(1) STREETER, G. L. 1920 Weight, sitting height, head size, foot length, and menstrual age of the human embryo. Contributions to embryology: No. 55. *Carnegie Inst. of Wash., Pub. No. 274*, pp. 145–170.

(2) MALL, F. P. 1910. Manual of human embryology, Vol. I, pp. 180–201; J. B. Lippincott & Co., Philadelphia, Pa.

(3) SCHULTZ, A. H. 1929 The technique of measuring the outer body of human fetuses and of primates in general. Contributions to Embryology: No. 117. *Carnegie Inst. of Wash., Pub. No. 394*, pp. 213–257.

Quotations on the Status of Dentistry (continued)

training and dental interest.—*G. H. Whipple, A.B., M.D., M.A., Sc.D., Dean and Professor of Pathology, School of Medicine and Dentistry, University of Rochester; and Trustee, Rockefeller Foundation: New York Journal of Dentistry*, 1931, i, p. 159.

Medicine and medical education have troubles of their own which will not be alleviated by attempting to swallow whole another profession; a profession, which, by and large, does not want to be engulfed. And a profession like dentistry, with a hundred-year history, deserves to have its feelings considered. You may call dentistry a specialty of medicine, but that does not make it so; and it is none the less valuable for that fact. I can see no reason why the degree, Doctor of Dental Surgery, honestly held and honorably upheld, should not in the future deserve equal respect and esteem from the public with the degree of Doctor of Medicine, provided it is held by a similar type of man. And whatever their future relationship may be, let medicine and dentistry now go forward side by side as friendly collaborators in the estimable undertaking of offering help to those who need it and adding to the happiness of life as much as to the length of its span.—*F. T. Van Beuren, Jr., A.B., M.D., Associate Dean, and Associate Professor of Surgery, Columbia University College of Physicians and Surgeons, New York City: Journal of the Association of American Medical Colleges*, March, 1932 (preprint, p. 10).

The stomatologist's concept of dental education and practice finds expression in the activities of a very limited group in this country who, so far as I can see, are making no headway in dissecting a part of the practice of dentistry from its whole and grafting it on medicine; nor do I believe that medicine would welcome such implantation. I have no apprehension over the stomatologist's point of view. In the four countries in Europe, Austria, Czecho-Slovakia, Belgium and Italy, where one must possess a medical degree to practise dentistry, the poorest type of technical dental service is to be found. In Switzerland, Sweden, Norway and parts of Germany, where dentistry is taught in conjunction with medical studies, yet independent of medical supervision, as we teach it in this country, the best type of service is found. Based on my own study of the problem in Europe [1926–27], I would both seek and recommend the services of dentists trained in the latter countries during the past decade and would avoid service in the former, unless I knew the dentist and his work personally.—*Guy S. Millberry, D.D.S., Dean, Dental School, Univ. of Calif.; Pacific Dental Gazette, 1931, xxxix, p. 415; June.*

Nothing is to be gained by converting a first-class dentist into a mediocre medical practitioner. . . . . I do not believe it is practical to unify the dental and medical curricula so as to provide for the same training of dentists and physicians during any considerable part of their academic careers. . . . . Dentistry is a very specialized field of medicine which has already been elevated to a standard of professional excellence entirely comparable with that of other medical specialties. *The average American dentist is at least as well qualified to render adequate service in his field of work as is the average otolaryngologist, ophthalmologist, or surgeon* [italic not in the original]. Dental education in America has been notably effective, and that is to the credit of the profession. . . . . Changes should not be made at the expense of that which has been found good through long practical experience. . . . . I am . . . . entirely unconvinced that any plan for the unification of the dental and medical curricula would result in the training of better qualified dentists. Dentistry is a profession which has become firmly established in its own right, and one which comprises a number of specialties. *It would lose much by becoming a minor subdivision of medicine* [italic not in the original]. It had best retain its independence.—*W. McKim Marriott, M.D., Dean and Professor of Pediatrics, Medical School, Washington University, St. Louis, Mo.; Journal of Dental Research*, 1931, xi, p. 807; October.

Important Books Received

The progress of dentistry and of the dental profession. Address (1924) by Charles W. Eliot, President Emeritus, Harvard University; also addresses (1924) by William H. Porter, Lieutenant Colonel, Dental Corps, U. S. A.; L. M. S. Miner, Dean, Harvard Dental School; and A. Lawrence Lowell, President, Harvard University. 1925: pp. 34; 5 x 2⅞ in.; 1 illustration; $0.75. Harvard Dental School, Boston, Mass.

Abnormal conditions of the teeth of animals in their relationship to similar conditions in man. By Sir Frank Colyer, K.B.E., F.R.C.S., L.D.S. 1931: pp. 167; 7¼ x 4⅝ in.; 217 illustrations; five shillings net. Dental Board of the United Kingdom, 44 Hallam St., W.1, London, England.

Practical physiological (biological) chemistry. By Philip B. Hawk, M.S., Ph.D., President of the Food Research Laboratories, Inc., New York City, and Olaf Bergeim, M.S., Ph.D., Associate Professor of Physiological Chemistry, University of Illinois, College of Medicine, Chicago, Ill. 1931: pp. 929; 7½ x 4½ in.; 287 illustrations; $6.50. P. Blakiston's Son and Co., Inc., Philadelphia, Pa.

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International Association for Dental Research: Proceedings of the Pittsburgh Section, May 18, 1931. *Lawrence E. Van Kirk*, B.A., D.D.S., M.S., F.A.C.D., *Editor* . . . 117

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